University of Texas Bulletin

No. 1839: July 10, 1918

ROAD BUILDING MATERIALS IN TEXAS

BY

JAMES P. NASH

IN COOPERATION WITH

L. L. BAKER, E. L. PORCH, JR., AND R. G. TYLER

BUREAU OF ECONOMIC GEOLOGY AND TECHNOLOGY
DIVISION OF ECONOMIC GEOLOGY
J. A. UDDEN, Director of the Bureau and Head of the Division

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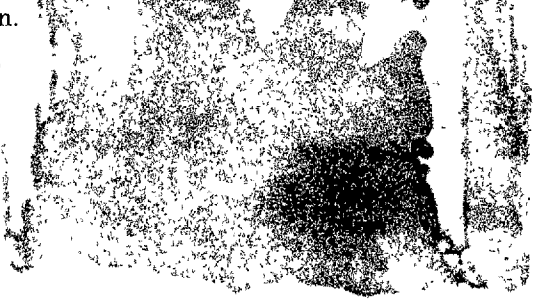

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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston

Cultivated mind is the guardian genius of democracy . . . . It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar

NOTE

This report was originally made at the request of Dr. Wm. B. Clark, Chairman of the Sub-Committee on Materials for Rapid Highway Construction, of the National Research Council, and comprised a detailed report on road materials available for use of the United States Army, in this state. The area covered that part of the state referred to by the Council as "behind the front"; that is, the tiers of counties bordering the Gulf Coast, and the Mexican border. Practically the entire staff of the Bureau was put at work on this report during the summer of 1917. As it was found that similar data could be collected, with comparatively little additional work, for the whole state as well as for the border country, the scope of the investigation was enlarged to cover the entire state. A report on the area designated by the National Research Council was completed in August, 1917, and copies were submitted to the War Department and to the Governor of Texas. Subsequently, under the direction of our Testing Engineer, Mr. James P. Nash, the data for the whole state were similarly compiled, and have within the last week been revised to date.

J. A. UDDEN.

Member, Sub-Committee on Materials for Rapid Highway Construction, National Research Council.

Austin, Texas,
May 6, 1919.

THE AVAILABLE DATA ON TEXAS ROAD MATERIALS

JAMES P. NASH

INTRODUCTION

With the great impetus given to road construction in the United States, and more especially in Texas, in the last few years, the necessity of proper methods in the construction and maintenance of our highways has been brought before the people. New methods of construction and better handling of the old methods have brought much improvement to the roads, but even with these more efficient methods, the new type of transportation over the roads within the past year or two has changed that which not long ago was considered the standard of perfection. With the employment of engineers skilled in highway construction, there has been a growing demand for knowledge regarding suitable materials for the roads. In the past year, on account of war conditions and the various embargoes placed on the railroads against hauling road materials, the use of local materials was fostered to the utmost. This was in many ways a good thing, for the reason that upon investigation it was found in many instances that deposits of satisfactory material, equal to that which was ordinarily shipped in, were located close at hand. In any event, there is a decided advantage in having a complete knowledge of the available deposits of materials for the reason that engineers unacquainted with local conditions are sometimes employed by the counties in constructing the roads. They must, therefore, take local opinion and ideas to guide them in their specification and in the materials which they use.

When the war broke out, the lack of military highways, or in fact any improved highways, along the border and the sea coast of this country stood glaringly before the Council of National Defense. In an attempt to rectify the error of unpreparedness of the past, this body made efforts to ascertain the various deposits of road material contiguous to the border and the sea

coast. The Director of the Bureau of Economic Geology was called into service to acquire and compile data regarding the location of various materials, so that, should an emergency arise, making it necessary to move troops to any point along the border or sea coast, at least the advantage would be possessed of knowing where materials for constructing the roads could be found. The Director, immediately upon request from the Council of National Defense, sent out questionnaires by mail and press throughout the state to collect all information regarding road materials, and this publication is the result of his efforts along this line.

Besides data and tests already at hand, a large volume of information on deposits which were obscure was acquired. It can be seen from the method of collecting these data, that some of them may not be as reliable as could be wished, being in many instances secured by parties inexperienced in matters of road construction. It is believed, however, that by far the greater part of the information contained herein is reliable and accurate. Some of it has been published in a previous report, namely, Bulletin 62 of the University of Texas, entitled "Road Materials of Texas". It is believed that the information will be valuable as a nucleus for the collection of still more comprehensive and more reliable data regarding road materials of this state.

DESIRABLE PROPERTIES OF ROAD MATERIALS

With the creation of the Texas State Highway Department in June, 1917, the movement for good roads in this state was greatly advanced, in that the matter of road building was placed on a state-wide basis, rather than on a county basis, as it was previously. State highways were planned to the extent of about 18,000 miles, which will form a network connecting practically every important center within the borders of the state, and also form parts of a definite system of national highways. Following this, came the demand for properly trained highway engineers to carry out the construction of these state highways. This was necessary in order to comply with the provisions of

the state and federal highway laws. The demands of traffic were such that the earth roads, previously satisfactory, would no longer suffice, since the automobile, and more recently the truck, must have a hard surface over which to travel. This, of course, demands greater expenditure of public money and a more careful supervision of its expenditure. The alignment and grading of roads were given more attention; the drainage structures took a more permanent form, such as concrete and steel, where previously wood had been used; and the surface material was necessarily of a better grade. The latter is probably one of the most important considerations from the financial standpoint, as in the average road this item represents about one-half of the total cost.

Ordinarily, the least thought is given to this question of materials, the argument advanced always being "We'll use what we have". It is usually much easier to ship the materials from some deposit already in operation, than it is to investigate the local materials. It often happens that the latter are as good as any materials that can be shipped, if not better, and local material can usually be obtained at smaller cost. A great many roads have been planned and contracts let before any attempt has been made to determine the material to be used.

While it is not always advantageous to use local materials, it is believed that the matter is important enough to deserve considerable investigation on the part of the engineer to determine what is the best material that can be obtained. After determining this point, more intelligent judgment can be given as to whether or not the cost is such that it would pay him to use inferior material at a less cost.

There are perhaps two or three times more gravel roads constructed in this state than roads of any other type, and this is as it should be, since Texas is bountifully supplied with gravel for road construction. In recent years, however, the matter of surface treating of roads has been brought to the attention of road builders from the necessity presented by the fast moving automobile and truck, which soon tear up and disseminate the finer particles from the road surface to the surrounding fields.

The surface treatment has proven quite satisfactory as a

maintenance proposition for these gravel roads, but as a rule, too much is expected from this type of bituminous mat construction. After all, the road itself, under the bituminous mat, must support the traffic. It has been found by experience that certain gravels are more satisfactory for the construction of these surface treated roads than others. The bituminous material, in order to be satisfactory, must have something to which it can adhere, and this is supplied by the pebbles making up the gravel. Fine silt or clay has not been found advantageous in this type of road, because, while the clay forms an excellent binder for gravel, it prevents the bitumen from properly adhering to the body of the road-bed. The bituminous material adheres to the fine particles of the silt and clay, which under the vibration of traffic become loosened from the pebbles and cause the mat to pick up under traffic. It has been found that the most satisfactory gravel, not only from the standpoint of an untreated road, but more especially for one which is surface treated, should contain a greater proportion of pebbles between ¼ inch and 2 inches than of other sizes. It is considered that the gravel should have between 60 and 70 per cent of pebbles which will grade well from ¼ inch to 2 inches. After all, it is these pebbles which give the body to the road, presenting a surface which will take the wear. It is necessary, of course, that the gravel should have sufficient finer particles of sand to fill in the interstices or voids between these larger pebbles so as to hold them in place, under traffic. A limited amount of clay is necessary to bind these particles together.

Ordinarily, from the nature of the material, there is apt to be a larger percentage of the finer pebbles of sand and clay than is desirable. A gravel of this latter type will usually compact on a road and present a uniform surface, but it does not present a surface to which bituminous materials will adhere well. Another matter which is very important is to eliminate all stones which are too large; say, 2 inches or larger. Such large stones will invariably work to the surface of the road, causing it to be very rough and uneven to traffic. An irregular surface spells a quick deterioration of the road, because impact, the great destroyer of roads, is increased.

It can readily be seen that if a vehicle, heavily loaded, strikes a rock protruding from the surface, it causes an impact when it strikes and another impact when it drops off the top of such a stone. It has been demonstrated that the pneumatic tired automobile has, comparatively speaking, little destructive influence upon a properly surfaced road, but a solid-tired motor vehicle or a steel-tired horse-drawn vehicle will cause a road to deteriorate very quickly, especially when it is somewhat rough. This is due, in a great measure, to impact. Therefore, it should be a paramount aim to eliminate anything which would tend to cause the surface to be rough. If a gravel is properly graded, up to two inches in size, all pebbles above this size should be screened from the gravel before it is placed on the road. With gravels composed of smaller sized pebbles, such as one graded up to one inch, the pebbles larger than this should be removed. In other words, the idea is to have the material uniformly graded so that no stones will be to any considerable extent larger than the rest. Sometimes an attempt is made to place these large sized stones in the bottom of the road, but this is a mistake. The vibration of traffic causes the finer stones to flow under them, causing these large stones to move upward and in a short while they protrude from the surface.

As has been mentioned above, the surface treated road is dependent in a great measure for its success upon the body of the road beneath. For this reason, where traffic is in any way heavy or dense, a special effort should be made to have this road of a type which will successfully withstand the traffic imposed upon it.

The crushed stone road is one which has been neglected to a great extent in this state, probably because of the prevalence of gravel. In Texas there are many deposits of good stone, equal to those found in most states in the Union. The limestones, as a whole, are satisfactory, but they have not been developed to any great extent, probably because the distribution of these rocks is not such that they can not be used over a wide territory. The deposits of trap rock are equal to those found anywhere in the United States, but their natural distribution is rather limited, so that only one commercial plant exists in this state.

For paving purposes, the granites in the central zone in Llano and Burnet counties are such that granite blocks for street paving and road work can be supplied which would support traffic as heavy as any in the City of New York. Numerous sandstones have also been located, but they are not considered satisfactory for ordinary macadam roads. Those in East Texas usually lack uniformity in quality and are, therefore, not of any value, except perhaps as concrete aggregate in the drainage structures.

For macadam road construction, those limestones having a coefficient of wear of more than ten, and a compressive strength greater than 10,000 pounds per square inch, are considered quite satisfactory There is a great number of places where these limestones can be used with a mobile crushing and screening plant. This usually requires a certain amount of equipment, not always possessed by the ordinary county, but it is firmly believed that this phase of road work will develop so that this method will be pursued much more than at the present time. There is no question but what a well constructed macadam road, surface-treated, will prove more economical than a gravel road, other things being equal.

In determining the relative qualities a rock should have in order to be satisfactory in macadam road construction, its resistance to wear and compressive strength are the items given the most consideration. These two properties will determine the actual usefulness of the material, although the other properties are also important. A rock having a coefficient of wear of ten and compressive strength of over 10,000 pounds per square inch, is considered as satisfactory for ordinary macadam or concrete road construction. Where there is no better material available, it is oftentimes advisable to use a rock having a coefficient of wear as low as eight, and a resistance to compression of 9,000 pounds per square inch.

The toughness test bears an important relation to the other tests, in that a rock having a high toughness will show a high resistance to wear and hardness. The converse of this, however, is not true, for a stone may have a low toughness and be high or low in resistance to wear or compressive strength. A granite

will usually be low in toughness on account of its granular structure, but invariably shows a high resistance to wear and compressive strength. Then too, there is another advantage in the toughness test, in that it gives some idea of the size of stones that should be used in constructing the road. For instance, if the toughness of a limestone is somewhat low, as is usually the case, this can be offset by the use of larger pieces. In other words, the resistance to impact of a stone is in a great measure determined by the size. A tough stone of small size will resist a blow equally as well as a large stone, low in toughness. As can be seen from the results of tests, the Texas limestones are all rather low in toughness, so that they should be crushed in rather large pieces.

The hardness test is of value as an index of internal wear of a stone in macadam road and surface wear in a concrete road. It is the measure of the resistance to separation of particles composing the stone. The pressure of vehicles over a macadam road surface causes local compression of the macadam and hence there is a slight movement of the individual stones on one another. This in turn causes a wearing action of the stones in the road, and their resistance to the wearing action is determined by the hardness test. In the case of the concrete road, this wearing action is entirely on the surface; as the road is a monolith there is no movement of the individual stones. A rock having a hardness of fourteen is considered satisfactory for ordinary road building. Where traffic is light, a lower hardness will do, but eleven or twelve is about as low hardness as should prove economical to use.

The absorption and weight per cubic foot give an index of the relative density of the rock. The latter, however, is useful in checking up quantities. When the percentage of voids is known, the weight of the broken stone can be determined. On the other hand, if the weight of the crushed stone is known, the voids can be determined.

The advisability of constructing concrete roads is now seldom questioned, especially for heavy traffic. In this type of construction gravel or crushed stone can be used equally as well, although it is believed that good wear-resisting stone is more to be desired. With the latter, the surface has a tendency to wear

more uniformly as all the stones are of equal hardness, but with the Texas gravel, this is seldom true. With this type of road, however, much greater skill is necessary in the proper manipulation of the materials and the proper selection of them. Here again, the aggregate should be well graded and of such size as to present a good wearing surface. It is necessary also that this be the case from the standpoint of strength of the concrete. Materials for a concrete road are usually selected with more care than is the case with the gravel road, for the reason, perhaps, that results are more disastrous from a failure of this type of construction. Not only must the coarse aggregate be selected with intelligence and care, but likewise the sand, and, needless to say, the cement. A coarse, well graded sand is considered the best, but it must also be free from clay or earthy material. Probably the greater amount of poor results from concrete road construction due to materials, can be traced to coatings on the aggregate. This is especially the case where gravel and sand are used, rather than where stone is used in the construction.

Proper grading of the coarse aggregate is essential. With crushed stone this is more apt to be obtained than with gravel, as the former can be regulated in a great measure in the artificial preparation necessary. Aside from this grading and clean condition of the aggregate, it is necessary that it have the wear-resisting qualities already mentioned. To a certain extent, the strength and wear-resisting qualities of the mortar should be equal to those of the coarse aggregate to the end that they both wear equally, thereby keeping the surface at all times in a uniform condition and thus reducing the chances for impact. Many gravels, being composed of hard and soft pebbles, produce a concrete road that will wear rough, due to the softer pebbles wearing away and leaving the harder ones protruding from the surface. These protruding pebbles are soon knocked out of the road bed, leaving a defective surface.

GENERAL DISTRIBUTION OF ROAD MATERIALS

As a general proposition, the most prevalent material in the state for road building is gravel. This is a very good thing for the reason that a large mileage of medium traffic roads can be

constructed with this material at a minimum cost. Furthermore, where this gravel and sand can be washed free of clay and other injurious materials, it can be successfully used as a concrete aggregate for bridges, culverts, or even concrete roads by the addition of cement and water. Thus it can be seen that we have available in gravel not only the material for the lighter traveled roads, but also one that may be used with correct handling for heavy traffic construction. Besides the gravels, there is an abundance of limestone over a considerable area of the state. While much of the limestone is not satisfactory for road construction, the hard and tough varieties make excellent roads. Along the coast country there is a dearth of suitable material, but shell dredged from the Gulf has supplied in part this lack of material for the lighter traveled roads. In certain restricted localities of the state, there is an abundance of granite suitable for the making of granite blocks, although up to the present time this has not been used to any great extent in the state. Most sandstones are in inaccessible localities or are not sufficiently indurated and are of variable character, so that little hope can be entertained for their use. There is, however, in this state a material that for heavy traffic road construction is unsurpassed. This is the basalt found as instrusives in a few localities along the Balcones escarpment. Caliche found in some parts of the state has been used for roads in the absence of other materials. Sand and clay suitable for the construction of sand-clay roads are found in a number of localities. They are, however, strictly of local importance, as a road constructed of any but local materials of this kind is not economical.

Considering the location of the various materials a little more definitely, it will be found that along the coast and paralleling it as far inland as one hundred miles, there are practically no natural deposits of satisfactory road materials, so that the matter of constructing first class highways in this country is a question of importing materials. The most accessible material is the shell dredged from the Gulf. This has certain disadvantages under modern traffic which must be considered before using it. With the addition of moisture, it compacts well under traffic into a hard, dense surface, but under considerable automobile traffic, it becomes very dusty and blows away, so that it is necessary to

continually replace it in order that the road be kept in anything like a satisfactory condition. Under considerable rainfall, it is apt to become rutted and pocketed. It can be seen, therefore, that to make it satisfactory under our modern traffic, and especially where motor trucks must be moved, it is necessary that the surface be kept free from excessive moisture and also that the dusting of the surface be prevented. For the lighter traffic roads, a surface mat of bituminous material has given a degree of satisfaction in meeting these conditions. Under heavy traffic, however, it is believed that a surface course having sufficient body in itself to withstand the shearing action of the traffic will be necessary. That is, the surface course should be at least two inches in depth, if of a resilient material such as bituminous macadam; and should have a greater depth, if of a non-resilient material such as concrete.

Farther inland, sands and clays are encountered, but they are only satisfactory under light traffic, for the reason that practically all the sand in this region is very fine in character, giving roads little stability. Toward the Louisiana line, the material acquires a ferruginous nature, which gives it better binding properties when compacted. Where gravels are found in this locality, they are composed of pebbles, all of which are small in size, and, under strict interpretation, are considered as sand-clays, being composed for the greater part of sand below one-fourth inches in size, and clay.

A narrow strip of indurated sandstone parallels the coast at a distance of about one hundred and fifty miles inland. It is approximately two hundred miles long. This sandstone varies from a fine quartz sand to a hard, quartzitic rock within the same ledge; sometimes but a few feet will contain all degrees of the induration, from the sand to the quartzite. The harder varieties, where found sufficient in quantity and uniformity to warrant use, should prove to be a good coarse aggregate for concrete road construction. For other types of road this material would not be so satisfactory. It has been found that bituminous materials do not adhere well to stones of this nature; and furthermore, in plain water-bound macadam construction, the rock has practically no cementing value, so that except for its merits as concrete road aggregate, this material has little to recommend

it. The softer varieties when properly handled will prove satisfactory as a concrete aggregate for bridges and culverts.

This sandstone deposit marks in a general way the area in which gravels may be found. As might be expected, for the most part the gravels in this section are made up of pebbles small in size and more nearly resembling sand-clays than gravels, from the standpoint of road construction. These gravels are mainly composed of flint and quartz pebbles with considerable good binding clays, and for light traffic are very satisfactory. Further inland as the Missouri, Kansas and Texas Railroad is approached, the coarser graded gravels are found, which are more substantial road materials for the reason that the pebbles are larger and give more body and wear to the road surface. The coarser graded varieties are generally composed for a considerable part of limestone pebbles mixed with the quartz and flint, but there are large quantities of gravels consisting exclusively of limestone. These are quite satisfactory for road construction after they have been compacted.

Running in a general north and south direction through the center of the state are found the most suitable limestones, especially those in the northern section of the state in the proximity of Wise County and southwest. In the region south of Lampasas and southeastward to Marble Falls, are found some of the hardest and toughest limestones in the state. The best limestones that have been tested have come from this locality. Strictly speaking, the material in question is a dolomite, which is merely a limestone with some of the calcium replaced by magnesium. Extensive areas underlain by this rock occur also on the Pedernales and on James River.

In this region, centered around Llano and Burnet counties, are also found the granites and gneisses. The close-grained varieties of these granites are suitable for making granite paving blocks and have been used to a limited extent for this purpose. It is reported that they have given satisfaction. Granites are not as satisfactory for the construction of bituminous roads as could be wished, for the reason that their crystalline structure, unless very fine, makes them low in toughness, and therefore they do not wear well. A hard gneiss such as found in this region, however, will make a satisfactory bituminous road. In fact, in many

parts of the United States, this material is classed commercially as trap-rock and has proven as satisfactory as the latter material for bituminous road construction. At the present time, these rocks are somewhat inaccessible to the railroads and have little importance from a commercial standpoint.

When these granites are weathered and disintegrated, they break up into so-called granite gravel, which has proved very satisfactory for road construction. This is due to the fact that the pebbles are sharp and angular, causing them to interlock to a considerable extent, as in a macadam road. They also contain some good binding clay which has been produced by the breaking down of the feldspars in the granite. The average material, however, is composed of stones rather small in size, mostly below a three-fourths inch sieve.

In the southwestern portion of the state, in the vicinity of Del Rio, are found limestone gravels in the beds of the rivers and also exposures of fairly hard limestones. Along the border in West Texas near the Big Bend country, there is an abundance of good road material of many kinds, including trap-rock, hard limestone, and gravels. In this country, however, at the present time, there is little demand for high-class roads, so that they are not of any great importance. In the Panhandle and the territory south of the Panhandle, there is, practically speaking, no material suitable for road construction, except for a few isolated gravel deposits. In this country, however, the earth roads have proved quite successful in handling the traffic.

ROAD MATERIALS BY COUNTIES

Anderson County

Situated in the northeast part of the state, this county lies in the sandstone region and the road materials found here are of this nature. Some more or less disintegrated sandstone is to be found, but the material which will probably prove more economical is the sandstone gravel. Care, however, must be exercised in the selection of these gravels for the reason that many of them are composed of badly decayed pebbles, which under heavy traffic, become broken up and soon disintegrate into a

dust. Where the pebbles are hard and fairly large in size, gravels of this nature make excellent roads for the reason that the iron oxide supplies good binding material. Several gravels have been tested in this county as follows:

MECHANICAL ANALYSIS

	No. 1	No. 2	No. 3	No. 4
Material retained on the 2-inch sieve	0	0	0	0
Material retained on the 1-inch sieve	3.0	1.1	0	0
Material retained on the ½-inch sieve	13.6	3.3	13.1	2.6
Material retained on the ⅛-inch sieve	58.0	33.0	64.8	36.3
Material retained on the .033-inch sieve	75.2	65.8	40.2	52.4
Material retained on the .0116-inch sieve	83.1	83.2	41.2	69.1
Material retained on the .0058-inch sieve	87.6	91.8	52.5	73.3
Material retained on the .0029-inch sieve	90.4	97.2	66.2	81.4
Material passing the .0029-inch sieve	0.6	.7	2.3	1.3
	100.1	100.2	99.9	100.0
Cementing Value on:				
Material over ⅛ inch in size	Excell.	----------	----------	Poor
Material under ⅛ inch in size	Good	----------	Good	Good
Material as received	Good	Excell.	Excell.	Good

No. 1. This material was found on the property of T. B. Greenwood, 1¼ miles east of Pasey Bridge Road, Anderson County, from Palestine. This sample is composed of rounded fragments of ferruginous sandstone with a large amount of sand and some clay. It should make a fairly satisfactory road building material due to its excellent binding properties.

No. 2. This material was taken from the city property, Palestine, about 1 mile northeast of Sycamore St., just outside the city limits. It consists of small fragments of a ferruginous sandstone with very little clay. Due to its very good cementing value, this material should prove satisfactory as a binder course for roads having a foundation course of larger material.

No. 3. This material was taken from city property, Palestine, on Spring St. The sample is a sand clay composed of fragments of sandstone with considerable clay. This material should make a satisfactory sand clay road, but necessarily lacks the wearing qualities of a gravel road.

No. 4. This material was taken on the F. H. Devenport property, about 2 miles northeast of Palestine, on Neches Road, Anderson County. It is a sand composed of fragments of ferruginous sandstone and considerable clay. It should prove satisfactory in sand clay construction, though it lacks the permanence of a gravel road.

Angelina County

This county lies at the edge of the sandstone deposits of the eastern part of the State. One material found in this county is loosely cemented quartzite and a semi-quartzitic sandstone. These deposits make up two isolated hills surrounded by low bottom lands in the valley of Shawnee Creek from ¼ to ½ mile above its junction with the Neches River. The shipping of this material might possibly be over the Carter-Kelley Lumber Company's tram, connecting at Manning with the Shreveport, Houston, Gulf Railroad. It is not considered a good road material, however.

A gravel known to be located at Flat Prairie in the vicinity of mile posts 108-110, inclusive, of the Texas & New Orleans Railroad. It contains great quantities of angular and sub-angular fragments of silicified wood. The shipping facilities are the Enal and Windom sidings on the Texas & New Orleans Railroad.

Atascosa County

This county lies also at the edge of the sandstone area. The sandstone and limestone in this county are rather poor material for road construction. The only limestone noted here is a white porous limestone on the hills from Lenz to Campbellton, which, if found satisfactory after examining the deposit, could be shipped over the San Antonio, Uvalde & Gulf Railroad.

A deposit of gray, flaggy sandstone about five feet thick, is located about 1-10 mile southeast of the junction of Falls City-Campbellton and Oakville-San Antonio roads, while at the junction of these two roads, a 10 foot deposit is found. The shipping point for these materials, should they prove of use, would be at Campbellton or Rhodo on the San Antonio, Uvalde & Gulf Railroad.

A deposit of sandstone, forty feet thick, is located 1½ miles southeast of Campbellton on the Campbellton-Brown City Road. This material could be shipped from the same point as that mentioned above. At a place seven miles south of Campbellton in a bluff on the Atascosa Creek and ¾ mile south of Old Whit-

sett's ranch house, is a deposit of sandstone from twelve to fifteen feet thick. The shipping point of this material would be Whitsett on the San Antonio, Uvalde & Gulf Railroad.

A sandstone conglomerate from this county was tested. The material was found about two miles northwest of New Pleasanton, on the Crystal City division of the S. A. U. & G. R. R. The results of the test follow:

Sp. Gr.	Wt. per cu. ft. Solid	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
2.80	175	2.14	27.6	1.4	18.5	2	good	7,600

This sample was sent to the laboratory by Edward Gillon. The test shows this to be a hard rock, having very low toughness and resistance to wear and good cementing value. It has rather low resistance to compression. Not recommended as a road material or for railroad ballast.

Austin County

A clay gravel owned by W. A. Mattbace, located ⅓ mile south of the Bellville-Hempstead Road and 1½ miles northeast of the G. C. & S. F. Railroad depot at Bellville on the I. P. Stephenson survey, was used on the streets of Bellville. The shipping facilities are not as good as could be hoped for, as the deposit is one mile east of the G. C. & S. F. Railroad, and 1⅓ miles from the station. A small sample of this gravel on hand indicates that it is a well-graded flint and quartz gravel with some sand and clay. Wm. H. Kluever, roadmaster of the G. C. & S. F. Railroad, is reported to have recommended it as a good ballasting and road gravel.

Bee County

No materials have been tested from this county, but there are several deposits of gravel and limestone worth while examining for their value as road materials. One white limestone is listed at the town of Mineral, but this is about eight miles from a rail-

road, so that should it be found to be satisfactory, which is doubtful, it could only be used locally. There are also numerous sections of white limestone from four to five feet thick between Beeville and Orangedale. A lime conglomerate with pebbles of siliceous rock two to five inches in diameter is found on the hills between Orangedale-Mineral Road. Between Caesar and Monteola is a thin deposit of flint gravel, but this is located over five miles from the San Antonio & Aransas Pass Railroad.

Bell County

The only rock listed from this county is a deposit of limestone seven miles west of Belton, three miles east of Nolanville, and ½ mile south of the Santa Fe Railroad on the John Hughes Survey. The property belongs to M. E. Whitmire, R.F.D. No. 7, Belton, Texas. The nearest railroad is the Santa Fe, ½ mile to the north. The deposit has never been worked, but is reported to be of considerable size, being one hundred feet high and one mile long. A small sample on hand indicates that the rock is soft and not suited for road construction except, perhaps, for very light traffic. No tests were made, however.

A number of deposits of gravel have been investigated by W. S. McGregor and are given here as reported by him. No samples were submitted for tests.

1. A pit owned by W. S. McGregor at Grace Spur on the M. K. & T. Railroad, ½ mile south of Little River Station: a very high grade of concrete gravel and about 200,000 cubic yards available with trackage.

2. A pit at Midway, five miles west of Temple on the Santa Fe Railroad, owned by the Quality Stone and Gravel Co. of Temple: contains about 300,000 cubic yards of fine concrete gravel and has trackage.

3. A pit near Sparks, on the land of Albert McKay, Sparks, Texas: contains a good deposit of road gravel, which has not been tested out thoroughly but estimated to contain about 150,000 yards of gravel. There is no trackage at present but the deposit is only about 100 yards from the M. K. & T. R. R.

4. One and one-half miles south of Sparks, there is a deposit of gravel half of which is road gravel and the other half is concrete gravel. It is within 100 yards of the M. K. & T. Railroad

and is owned by a brother of Dr. V. E. H. Reed of Holland, Texas.

5. One mile north of Holland, Texas, the M. K. & T. Railroad divides a gravel deposit on the farm of Mr. Duncan of Bartlett. Gravel has been taken from this deposit for road construction, but there is a somewhat limited quantity, only 60,000 yards being available. No trackage exists, but the gravel is right off the railroad.

6. Near Sparks, there is a fine deposit of concrete gravel on the farm of Ex-Governor James E. Ferguson, some of which has been used on the roads in the vicinity, with success. There are possibly 200,000 yards of gravel in the deposit, but it is about one mile east of the M. K. & T. Railroad.

7. On the McGregor pit at Grace Spur, south of Little River, there is a deposit of good road gravel owned by Senator J. B. Buchanan of Temple, which contains approximately 200,000 cubic yards and is about 1,000 feet from the M. K. & T. Railroad tracks.

8. Geo. Beard of Little River, owns a deposit of good gravel near Grace Spur, about 1,000 feet from the M. K. & T. Railroad. This contains approximately 60,000 cubic yards of gravel.

The following gravels from this county were tested and resulted as follows:

MECHANICAL ANALYSIS

	No. 1	No. 2	No. 3	No. 4	No. 5
Material retained on 2-inch sieve	0	0	0	0	0
Material retained on 1-inch sieve	6.3	15.0	1.9	12.0	4.4
Material retained on ½-inch sieve	19.7	46.5	16.7	33.6	12.0
Material retained on ⅛-inch sieve	62.1	75.1	71.2	68.0	53.7
Material retained on .033-inch sieve	78.0	80.4	90.5	81.6	68.3
Material retained on .0116-inch sieve	80.9	82.9	97.9	93.2	74.5
Material retained on .0058-inch sieve	81.9	84.2	98.9	94.9	77.4
Material retained on .0029-inch sieve	82.8	84.6	99.2	95.6	79.0
Material passing the .0029-inch sieve	16.9	15.7	.1	4.4	21.0
Total	99.7	100.3	99.3	100.0	100.0
Cementing Value on:					
Material over ⅛ inch in size	Poor	Good	Poor	Good	Excell.
Material under ⅛ inch in size	Fair	Excell.	Fair	Excell.	Excell.
Material as received	Poor	Good	Poor	Excell.	Excell.

No. 1. This sample was sent by Mr. E. A. Kingsley, Temple, Texas, from the Murray pit, four miles east of Troy. The gravel is composed of fragments of limestone with a large amount of fine calcareous material. It contains too much fine material and not enough large stones to be satisfactory in gravel road construction. Should make a good binder course on a foundation of larger material.

No. 2. Sample sent to laboratory by Mr. E. A. Kingsley, Tem-

ple, Texas, from the pit of J. S. Fowler, six miles west of Temple, near the old Howard Road. The gravel is composed of more or less rounded fragments of limestone with considerable calcareous, fine material. It should prove satisfactory as a road gravel. Its durability would be greater, however, if it contained more stones between one and two inches in size.

No. 3. Sample from the McGregor Gravel Co. of Temple, Texas. The gravel consists essentially of hard pebbles of limestone, with some quartz sand. The stones are covered with an iron oxide clay. The material contains too much small stones to be recommended for road construction. It might prove satisfactory under light traffic.

No. 4. Sample from pit near Midway on the south side of the road. The test was made by the Office of Public Roads at Washington, D. C. Sample consists essentially of large rounded fragments of limestone, quartz, and calcareous shells with a considerable amount of calcareous sand. The percentage of fine material in this gravel is too low for best results in gravel road construction.

No. 5. Sample from pit on the Santa Fe, north of road at Midway and owned by the Santa Fe. The tests were made by the Office of Public Roads at Washington, D. C. Sample consists essentially of rounded fragments of limestone and quartz with a large amount of ferruginous quartz sand and clay. Gravel contains too much fine material to be satisfactory for use in gravel road construction.

Bexar County

A limestone quarry was reported by the owner, D. M. Picton Company of Port Arthur, Texas, to be producing about 1,000 tons of rock per day. This quarry is on the San Antonio & Aransas Pass Railroad, 20 miles west of San Antonio. This stone has been used in the construction of some of the streets in San Antonio. No test has been made.

Another limestone at Olga, fourteen miles west of San Antonio, on the San Antonio & Aransas Pass Railroad, was reported by Joe Beckman, 117 West Euclid Ave., San Antonio, the owner having received the blue ribbon at the St. Louis Exposition for the best lime burning rock in the United States. At one time it was used for this purpose, but at the present time it is not operated.

Several gravels were tested and the results are given below together with the locations of sampled deposits:

MECHANICAL ANALYSIS

	No. 1	No. 2	No. 3	No. 4
Material retained on 2-inch sieve	10.6	0	0	6.9
Material retained on 1-inch sieve	27.1	0.2	33.4	21.7
Material retained ½-inch sieve	47.9	3.8	49.9	39.7
Material retained on ⅛-inch sieve	78.5	54.8	65.9	60.3
Material retained on .033-inch sieve	87.6	81.3	73.9	74.8
Material retained on .0116-inch sieve	91.7	89.8	77.8	85.6
Material retained on .0058-inch sieve	93.1	92.1	79.4	88.9
Material retained on .0029-inch sieve	93.5	92.7	80.5	90.7
Material passing the .0029-inch sieve	6.7	6.7	19.6	8.9
Total	100.2	99.4	100.1	90.6
Cementing Value on:				
Material over ⅛ inch in size	Poor	Poor	Poor	Poor
Material under ⅛ inch in size	Fair	Poor	Good	Poor
Material as received	Poor	Poor	Fair	Poor

No. 1. This gravel was taken from a hill west of Leon Creek, 7 miles west of San Antonio. It consists of rounded fragments of hard limestone fairly well graded. It should prove satisfactory in gravel road construction.

No. 2. This gravel was taken from a hill west of Leon Creek, Castroville Road, much used as top dressing on local roads. It is composed of more or less rounded fragments of limestone over 75% of which is sand. This material is not recommended as a road building material. To be satisfactory it should contain about 70% of stones between ⅛" and 2" in size.

No. 3. Prospect Pit, 4½ miles east of San Antonio, and about ¼ mile north of St. Hedwig's Road near the east bank of Salado Creek. This gravel consists of large rounded fragments of flint well graded down with a large amount of clay. The material under 2" sieve only, was used for this test as the stones above this size should be removed from the material before it is used in the roads. A satisfactory road material.

No. 4. Six miles southeast of San Antonio, and about 50 yards south of Gonzales County Road. This material contains fragments of soft limestone with considerable calcareous sand. Due to the soft nature of the material making up this gravel, it is only recommended for very light traffic roads.

Bowie County

E. W. Hookings and associates, of Nash, Texas, own a gravel pit six miles west of Texarkana and ¾ mile north of the Cotton Belt Railroad on the Eylau-Texarkana Road. During 1916,

there were about five hundred cubic yards of this gravel produced. No tests have been made.

Another pit one mile east of Texarkana, on the St. L. & I. M. S. R. R., and still another pit three miles west of Texarkana on the S. L. & S. W. R. R., belong to Young and F. Low of Texarkana, Texas. These pits load about seventy-five cars of gravel per day. Some of the gravel was used on the roads in Bowie, Harrison, and Red River counties.

Brazos County

Some soft and hard limestones are located southwest of Millican on a spur of the H. & T. C. R. R. This belongs to the Texas Rock Company of Beaumont, W. E. Sampson, Manager. About ten cars of this material are produced in a day, primarily as a concrete aggregate. It was used for the base of the Brazos County roads. No tests have been made on the material. About one mile from Yuma, on the I. & G. N. R. R., is located a gravel deposit belonging to J. D. Steele of Millican, Texas. The pit has never been worked, but is close to the I. & G. N. tracks It is reported to be very similar to the gravel used on the Brazos County roads. The deposit is about nine feet in depth and of considerable extent.

Brewster County

Most of the materials satisfactory for road construction in this county are igneous rocks, that is, those rocks formed by the cooling of the molten materials from the interior of the earth. The fine grained varieties of these rocks, such as the diabases and basalts, are considered the best type of stone for road construction to be had. The granites are of crystalline structure and are consequently less desirable for road construction. Some of the locations of these igneous rocks are given here. An undetermined igneous rock is located twelve miles east of Terlingua at the Maverick Mountain.

A large number of porphyries is found in this county. In Santiago is located a syenite porphyry, 1,650 feet thick, while in the near vicinity of the peak is a number of other deposits.

Two locations of this material are found in the Mt. Ord Range, three or four miles west of Capt. James' ranch-house, just north of the old Marathon-Alpine Road. Another syenite prophyry is located in Iron Mountain, north of Marathon. A small quarry has been opened on the south face. The Rosillos Mountains contain considerable feldspar-porphyry and north of Banta Shut-up around Stillwell's ranch is located another. The northeastern projection of the Chisos Mountains, extending over several square miles, is a mass of porphyritic andesite, also the Corazones Peaks are composed in part of a porphyry. A quartz porphyry forms the rim rock of the Chisos Mountains rising to a height of more than two thousand feet and covering eight to ten square miles. It forms the top of Emory Peak. A heavy sheet of lava forms the high bench east of Ash Gap and north of Ward Gap, while thinner flows of lava with vesicular structure are located between Oak Gap and Ward Gap. A black porphyry known as Black Peak rises from the plain about four miles northeast of Box Spring.

A small outcrop of rhyolite is found in the vicinity of Dog Canyon west of the junction of Calamity and Maravillos Creeks, while another light-colored, very hard, silicified rhyolite is found at Study Butte and Black Mesa in the Terlingua District.

A seventy foot sill of andesite is exposed in a line of hills extending to the southeast from the east side of Terlingua Creek opposite Dryden's Ranch.

To the east of the Chisos Mountains a diorite is found. It is particularly conspicuous on the west side of the Sierra del Carmen and about three miles east of Mailbox Tank. It is about fifty feet thick at a point about four miles east and one mile north of McKinney Springs. A sill along the west side of Mariscal Mountains and a number of smaller dikes and sills in the vicinity of the Chisos Mountains are found.

A number of trap rocks is found in this county that should be worth while investigating. Small knobs of diabase are located between the head of Maravillas Canyon and the Marathon Basin. Basalts are found in the Clay Mountains near Terlingua and in the foot hills of the Mesa de Anguila near the Grand Canyon of Saint Helena on the Rio Grande. This is a dense, black, coarse-grained rock. Another basalt is found at the Bee Cave Tank

and southward on the road from Marathon to the mouth of Stillwell Canyon, also between Maravillas Canyon and the eastern base of the Sierra del Carmen.

A phonolite is found in the California Hill, near Terlingua. This is greatly weathered, greenish grey, rather fine-grained and porphyritic and when fresh, breaks with conchoidal fracture.

Various volcanic rocks are found in the vicinity of Terlingua, California Hill, Clay Mountain, Black Mesa. Many other localities are known along Fresno Creek, two small mesas near McKinney mine, and a lava flow 1 1-2 miles north of this mine. Lava is common in the valley of Terlingua Creek. There are several hundred feet of lava at Cigar Springs Mountain, forty feet of lava at Study Butte east of Terlingua Creek. A high plateau of volcanic rock extends from the Davis Mountains to Fresno Canyon sloping gradually southwards from the Alamito great lava flows along Fresno Canyon. A hard felsitic lava is located in the Smuggler's Canyon on the west side of Burro Mesa.

The roads around the camp of the Chisos Mining Company at Terlingua are surfaced with a lime shell taken from the mines. It is estimated that the daily output is about two hundred tons per day.

Some gravel is also found in this county. One deposit on the west side of Tornillo Creek and northwest of Boquillas is found in an oval area about twelve miles long and four miles wide. In Rice's Canyon gravels are plentiful, but most of the gravels in this general region are found in terraces at the junctions of tributaries with the main stream and in arroyos.

Brown County

The only material on record from this county is a limestone from 1-2 mile southwest of Brownwood, owned by Hall Brothers, and operated by M. J. Hall, Brownwood, Texas. It is reported that the Santa Fe Railroad contemplates putting in a crusher to use the stone for ballast. With the present equipment the plant can turn out about two hundred yards of material per day. While no complete tests have been made on this material, a partial test made in the laboratory resulted as follows:

Spec. Grav.	Wt. per cu. ft.	Absorption lbs. per cu. ft.	Crushing Strength 2-inch cube
2.70	168	0.54	18,300 lbs. per sq. in.

While these tests are too incomplete to warrant making a recommendation of the material, the high crushing strength would indicate a favorable test.

Burleson County

Some rock (not named) belonging to the Texas Rock Company of Beaumont, Texas, is located one mile north of Sand Pit and about ¾ mile from the Santa Fe Railroad. This deposit has never been operated.

A sandstone belonging to Mrs. M. L. G. Stone is located ¼ mile from Sand Pit on a spur of the G. C. & S. F. Railroad. Some of this rock has been used in jetty work.

Another sandstone, located one mile north of Clay Station, at Koontz Hill and a few yards east of the public road, belongs to Mrs. M. McCreery, Independence, Texas, and R. Kaye, East Side Avenue, Dallas, Texas. This rock is located one mile from the Sante Fe Railroad and has never been worked.

A sandstone from the property of W. T. Dunlap, Somerville, Texas, located at Sand Pit, one mile from Clay, and fourteen miles east of Somerville and one mile from the G. C. & S. F. Railroad was tested in the laboratory with the following results:

Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
	140	3.5	4.2	9.6	16.7	14	Fair	

The tests show this to be a medium hard rock, with medium resistance to wear and toughness, and fair cementing value. The appearance of a small sample on hand indicates that the stone is an even-grained, fairly hard gray sandstone. Should be suitable as a railroad ballast or as a foundation course for a macadam road. Crushed to proper size it should make a good concrete aggregate. The tests were made by the Office of Public Roads at Washington.

Burnet County

Like Brewster County, there are many and varied types of road materials found in this county. The hardest and best limestone rocks known in Texas are located here. These are the dolomites. Some sandstones are also to be found in this locality, but more abundant are the granites and their weathered products, namely, the disintegrated granites. These latter deposits, being easily handled and quite satisfactory for many roads, have been used more than any other material from the county.

Tests have been made on many of the dolomites and are included in the table below, each test numbered so as to correspond to the location and remarks:

No.	Wt. lbs. per cu. ft.	Abs. lbs. per cu. ft.	French Coef of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	175	0.29	16.4	15.6	11	53	26,250
2	175	0.46	15.6	17.3	8	43	26,000
3	175	0.39	13.8	16.3	9	25	22,000
4	175	0.44	12.9	16.3	7	17	16,725
5	175	0.35	11.3	16.1	8	41	25,000
6	175	0.53	11.8	15.7	7	42	15,770
7	175	0.22	10.2	15.8	7	40	19,100
8	175	0.59	9.8	16.3	9	18	18,150
9	175	0.34	10.9	15.5	4	18	16,440
10	172	0.40	7.5	15.2	6	80	16,830
11	175	1.03	10.0	14.1	4	19	18,650
12	168	1.90	8.6	12.8	5	20	19,000

No. 1. Bryant Ranch, about ¾ mile down Hamilton Creek, below Holland Spring, at point where the Holland branch empties into Hamilton Creek, about ¾ mile east of A. &. N. W. Railroad, and about three miles south of Burnet, Burnet County.

This rock has a high resistance to wear, medium hardness, low toughness, good cementing value and very high resistance to compression. This rock should make a very satisfactory material for water bound macadam roads under medium traffic and bituminous macadam or concrete roads under heavy traffic.

No. 2. Reed Yett's land, about ½ mile east of A. & N. W. Railroad and about five miles east of Fairlands, Burnet County, on Honey Creek, below the bridge.

This rock has medium hardness, high resistance to wear, low toughness and good cementing value. It has very high resistance to compression. This is a very satisfactory material for both plain and bituminous construction. It should also make an ex-

cellent railroad ballast or concrete aggregate for road construction.

No. 3. Reed Yett's land, about two hundred yards south of A. & N. W. Railroad and about 1¾ miles east of Fairlands, Burnet County, east of ranch house.

This rock has medium hardness and resistance to wear, low toughness and good cementing value. It also has a very high resistance to compression. This rock should make a satisfactory material for plain macadam roads subject to medium traffic or under heavy traffic with a bituminous binder. The material should also make an excellent railroad ballast or concrete road aggregate.

No. 4. Reed Yett's land, about ½ mile south of A. & N. W. Railroad and about 1¾ miles southwest of Fairlands, Burnet County.

This rock has medium hardness and resistance to wear, low toughness and fair cementing value: it has also high resistance to compression. This material should prove very satisfactory for plain or bituminous macadam roads subject to medium traffic and also as an aggregate for concrete roads.

No. 5. R. H. Hoover's land, about ½ mile east of A. & N. W. Railroad and about 6 miles east of Fairlands, Burnet County, about ¼ mile down Hamilton Creek from pumping station. This rock has medium hardness and resistance to wear, low toughness, good cementing value and very high resistance to compression. This material should prove very satisfactory for plain macadam roads subjected to medium traffic or under heavy traffic with bituminous binder or in concrete roads.

No. 6. Reed Yett's land, first creek north of Sudduth section-house, on A. & N. W. Railroad, Burnet County, about ½ mile down the creek. This rock has medium hardness and resistance to wear, low toughness, good cementing value and fairly high resistance to compression. This material should prove very satisfactory as a road building material under medium traffic. It is also a very good railroad ballast and aggregate for concrete roads.

No. 7. Reed Yett's land, about ¾ mile up Honey Creek, Burnet County, from the crossing of the A. & N. W. Railroad and about ¼ mile west of the track, about 5 miles east of Fairlands. This rock has medium hardness and resistance to wear, low toughness, good cementing value and high resistance to compression. This material is recommended for the construction of medium traffic roads. Should make a good concrete aggregate for road construction.

No. 8. Dave Holland's land, about 1 mile south of A. & N. W. Railroad and about 1¾ miles southwest of Fairlands, Burnet County. This rock has medium hardness and resistance to wear, low toughness, and fair cementing value, and high resistance to compression. This rock should prove satisfactory for medium traffic plain or

bituminous macadam construction. It should also make an excellent railroad ballast or concrete aggregate.

No. 9. Reed Yett's land, about ¼ mile west of A. & N. W. Railroad and about 5 miles northeast of Fairlands, Burnet County, on Honey Creek, above the bridge. This rock has medium hardness and resistance to wear. It has very low toughness, fair cementing value and high resistance to compression. This material is only recommended for bituminous road construction or as an aggregate for concrete roads.

No. 10. Reed Yett place, about ½ mile up Honey Creek, from A. & N. W. Railroad bridge, Burnet County, about ¼ mile west of track, about 5 miles east of Fairlands. This rock has medium hardness and resistance to wear, low toughness, very good cementing value and fairly high resistance to compression. This rock is recommended for light traffic waterbound macadam or for medium traffic bituminous construction, also as a concrete aggregate.

No. 11. E. O. Wengren's land, about ½ mile east of A. & N. W. Railroad and about 6 miles east of Fairlands, Burnet County. About ¼ mile up Hamilton Creek from its junction with Delaware Creek. This rock has medium hardness and resistance to wear, low toughness, and fair cementing value, and a high resistance to compression. On account of its low toughness and rather low cementing value, this rock is only recommended for bituminous construction. The stone should make a good railroad ballast and aggregate for concrete roads.

No. 12. R. H. Hoover's land, immediately on track of A. & N. W. Railroad west side of Delaware Creek, and about 6 miles east of Fairlands, Burnet County. This rock is low in hardness and toughness with medium resistance to wear, fair cementing value and high resistance to compression. This rock is recommended only for bituminous construction, and should make a very good railroad ballast or aggregate for concrete roads.

Besides these dolomites which are unquestionably the best road building stone of a calcareous nature in the state, there are some very good limestones in this county many of which could be used commercially in road construction. Quite a number of these limestones have been tested and the reports are given below:

No.	Wt. lbs. per cu. ft.	Abs. lbs. per cu. ft.	French Coef of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	165	0.67	16.1	18.2	14	42	24,500
2	165	1.67	14.8	15.7	16	118	19,950
3	165	0.72	14.6	16.3	9	28	17,700
4	168	0.31	13.5	16.0	6	72	18,860
5	168	0.44	13.3	16.8	7	50	15,425
6	168	0.30	12.3	16.4	6	81	18,575
7	168	0.25	13.2	17.8	6	25	15,025
8	168	1.11	14.4	14.7	5	87	16,250
9	168	0.33	12.3	15.2	5	49	13,085
10	168	0.53	13.0	14.5	7	12	16,250
11	168	0.22	12.1	13.4	4	76	12,575
12	168	0.76	9.7	15.2	5	78	10,040
13	172	0.42	11.1	14.5	7	21	17,000
14	168	0.69	11.3	15.2	5	23	16,100
15	168	0.19	12.1	14.8	4	33	13,160
16	162	1.70	11.5	13 7	6	34	11,075
17	168	0.55	8.7	15.2	7	74	9,975
18	153	3.62	11.0	13.2	6	24	11,160
19	168	0.81	8.8	15.3	3	70	11,860
20	168	1.94	8.3	16.5	4	49	10,875
21	168	0.17	10.0	14.7	4	17	16,850
22	168	0.17	11.3	11.5	5	54	12,100
23	175	1.16	8.9	13.7	6	34	13,140
24	168	0.26	9.0	15.1	4	21	11,065
25	168	1.58	9.8	10.8	4	19	12,475
26	168	0 52	8.0	12.0	4	28	11,000
27	168	0.32	11.7	14.8	3	42	14,350

The locations and remarks regarding the above samples follow:

No. 1. Backbone Creek (Lacey's pasture), about ½ mile east of A. & N. W. Railroad, where creek cuts through ridge, about 1¼ miles north of railroad station at Marble Falls. This is a hard rock with high resistance to wear, medium toughness, good cementing value and very high resistance to compression. Should make a very good material for medium or heavy traffic plain macadam construction or surface treated road, but the stone breaks with a smooth fracture that might cause some difficulty in bituminous construction from the bitumen not sticking.

No. 2. About 1 mile northeast of A. & N. W. station at Marble Falls, Burnet County, and ½ mile east of high school building. This rock has medium hardness and toughness, high resistance to wear, excellent cementing value and high resistance to compression. Should make an excellent material for medium traffic roads in plain macadam construction or under heavy traffic in bituminous construction.

No. 3. Reed Yett's land, about ¼ mile north of A. & N. W. Railroad and about 1½ miles east of Fairlands, Burnet County, top of hill. This rock has medium hardness and resistance to wear, low toughness, and good cementing value. It has also high resistance to compression. Should make a very good material for medium

traffic plain macadam roads or under heavy traffic bituminous roads.

No. 4. Ferguson place, near Fairlands, Burnet County. Within a half mile of the A. & N. W. Railroad. This limestone rock shows medium hardness and resistance to wear, low toughness and good cementing value. It has also high resistance to compression. Should prove very satisfactory for medium traffic roads in plain macadam and for heavy traffic bituminous roads. Excellent railroad ballast and concrete aggregate.

No. 5. At Hoover's Point, about 1¼ miles east of Colorado River bridge and directly on the A. & N. W. Railroad. This rock is of medium hardness and resistance to wear, low toughness, and good cementing value and has fairly high resistance to compression. It should prove very satisfactory in plain macadam construction having medium traffic, or in bituminous construction. It should also make a good railroad ballast or concrete aggregate.

No. 6. Cut through Backbone Ridge, A. & N. W. Railroad, about 1 mile north of Marble Falls, Burnet County. This rock has medium hardness and resistance to wear, low toughness, very good cementing value and has high resistance to compression. It should prove very satisfactory in plain macadam construction, under medium traffic, or under heavy traffic in bituminous construction. It should also make good railroad ballast or concrete aggregate if crushed to proper size and grading.

No. 7. R. H. Hoover's land, about ½ mile east of A. & N. W. Railroad and about 6 miles east of Fairlands, Burnet County, about 150 yds. above pumping station on Hamilton creek. This is a hard rock with medium resistance to wear, low toughness, and good cementing value. It also has high resistance to compression. This rock should give good results in plain macadam construction under medium traffic or under heavy traffic in bituminous construction.

No. 8. R. H. Hoover's land, about 1 mile south of Delaware water tank, A. & N. W. Railroad, Burnet County, and 400 yds. west of railroad cut. This is medium hard rock with a high resistance to wear, low toughness and good cementing value. It also has a fairly high resistance to compression. This rock is recommended for light traffic waterbound macadam, ballast, or concrete aggregate.

No. 9. R. H. Hoover's land, about 1 mile up Honey Creek from crossing of A. & N. W. Railroad, and about ¾ mile from the railroad, Burnet County. This rock has medium hardness and resistance to wear, low toughness and good cementing value, and fair resistance to compression. This material should prove satisfactory under medium traffic roads.

No. 10. About ¾ mile north of Sudduth sectionhouse on A. & N. W. Railroad, Burnet County, west side of the railroad and up the creek about 450 yds. This rock has medium hardness and

resistance to wear, low toughness, fair cementing value and fairly high resistance to compression. This rock is recommended for roads having medium traffic in waterbound and bituminous construction. Should also make a good railroad ballast and concrete aggregate.

No. 11. Reed Yett's land, about ¼ mile west of A. & N. W. Railroad and about 5 miles northeast of Fairlands, Burnet County, on Honey Creek, above the bridge. This is a rather soft rock, low in toughness, medium resistance to wear and very good cementing value. It also has fair resistance to compression. This material is satisfactory for light or medium traffic plain macadam roads. Should also be satisfactory in bituminous construction.

No. 12. Ferguson place, near Fairlands, Burnet County. Within half a mile of the A. & N. W. Railroad. This rock shows medium hardness and resistance to wear, low toughness and very good cementing value. It has fair resistance to compression. This material is satisfactory for plain macadam roads subject to medium or light traffic or in bituminous construction under heavier traffic conditions.

No. 13. Lefthand fork of Wood's Branch above Wood's sandstone quarry, Burnet County. This limestone has medium hardness and resistance to wear, low toughness and fair cementing value. It also has high resistance to compression. Should prove satisfactory for plain macadam roads subject to light traffic or in bituminous construction. Should also make a good railroad ballast or concrete aggregate.

No. 14. Reed Yett's land, about ½ mile north of A. & N. W. railroad and about 1¾ miles east of Fairlands, Burnet County. This is a medium hard rock with medium resistance to wear, low toughness and fair cementing value. It also has high resistance to compression. This material is recommended for light traffic in plain macadam construction or under medium traffic in bituminous construction.

No. 15. About ½ mile east of A. & N. W. Railroad and about 6 miles east of Fairlands, about ¼ mile down Hamilton Creek from the pumping station on the property of R. H. Hoover. This rock has medium hardness and resistance to wear, low toughness and good cementing value. It has fair resistance to compression. Due to the low toughness of this rock, it is only recommended for light traffic, waterbound, or bituminous roads.

No. 16. Reed Yett's land, about ¼ mile north of A. & N. W. Railroad and about 1½ miles east of Fairlands, Burnet County. Center of hill. This is a soft rock low in toughness and resistance to wear. The rock is recommended for light traffic or in bituminous construction.

No. 17. A. H. Edward's land, about 1 mile east of A. & N. W.

Railroad and about 1½ miles east of Fairlands, Burnet County; top strata. This rock has medium hardness and resistance to wear, low toughness and good cementing value. It has rather low resistance to compression for material of this kind. Should prove satisfactory for medium traffic roads in plain macadam construction, or in bituminous construction. This sample is better than from the bottom or center of the deposit.

No. 18. One-quarter mile north of A. & N. W. Railway, about 1½ miles east of Fairlands on property of Reed Yett. This rock has low hardness and toughness, medium resistance to wear, and fair cementing value. It has fair resistance to compression. This material is recommended only for light traffic in waterbound macadam roads. Should give good results under medium traffic, if a bituminous binder is used.

No. 19. At Hoover's Point, about 1½ miles east of Colorado River bridge and directly on the A. & N. W. Railroad. This rock has medium hardness and resistance to wear, low toughness and good cementing value. It has fair resistance to compression. Should be used only in plain macadam roads subjected to light traffic, due to its low toughness.

No. 20. About 1 mile east of A. & N. W. Railroad, and about 1½ miles southeast of Fairlands, Texas. Center stratum. Property of A. H. Edwards. This siliceous limestone has medium hardness and resistance to wear, low toughness and good cementing value. It has fair resistance to compression. Should prove satisfactory only in plain macadam construction subjected to light traffic.

No. 21. Reed Yett's land, about ½ mile east of A. & N. W. Railroad and about 5 miles east of Fairlands, Burnet County, on Honey Creek, below the bridge. This rock has medium hardness and resistance to wear, low toughness and fair cementing value. It has also good resistance to compression. This material will do for plain macadam construction under medium traffic conditions, but would prove more satisfactory with bituminous binder due to its low toughness and cementing value. Should make a good railroad ballast or concrete aggregate.

No. 22. R. H. Hoover's land. Burnet-Marble Falls Road, hill just north of Hoover's ranch house, Burnet County, about 1 mile west of A. & N. W. Railroad, and about 3½ miles southwest of Burnet. This rock has medium resistance to wear, low hardness and toughness, good cementing value and fair resistance to compression. This material is recommended only for light traffic waterbound macadam roads or bituminous macadam construction having medium traffic.

No. 23. Right hand fork of creek above Wood's sandstone quarry. This limestone is somewhat low in hardness, with medium resistance to wear, low toughness and good cementing value. It

has fair resistance to compression. This rock should be satisfactory for light traffic roads. It should also make satisfactory railroad ballast or concrete aggregate if crushed to proper grading.

No. 24. Widow Holland's ranch, about 1½ miles southeast of Burnet, Burnet County, and about ¾ miles east of A. & N. W. Railroad, east side of Hamilton Creek. This rock has medium hardness and resistance to wear, low toughness and fair cementing value. It has, also, fair resistance to compression. This sample is recommended only for light traffic in waterbound macadam roads or under medium traffic in bituminous construction.

No. 25. From cut on A. & N. W. Railroad, 1 mile south of Delaware water tank. Burnet County. This rock has medium resistance to wear, low hardness and toughness and fair cementing value. It has also fair resistance to compression. Recommended only for light traffic roads.

No. 26. About 1 mile east of A. & N. W. Railroad and about 1½ miles southeast of Fairlands, Texas. Bottom stratum. Property of A. H. Edwards. This rock has medium resistance to wear, low hardness and toughness and good cementing value. It has fair resistance to compression. It is recommended only for plain macadam roads subject to light traffic.

No. 27. A short distance south of Honey Creek, west side of A. & N. W. Railroad, Burnet County. This rock has medium hardness and resistance to wear, very low toughness, good cementing value and fair resistance to compression. Not recommended as a road material.

Sandstone is another variety of rock found in this county. A deposit has been worked thirteen miles southeast of Burnet and three miles from Fairlands, on the property of T. B. Woods, Marble Falls, Texas. A three mile spur runs from this quarry to the H. & T. C. Railroad (Austin-Llano Division). Some streets have been paved with blocks cut from this material and it has also been used as a building stone.

Tests of this material have been made resulting as follows:

Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
2.45	153	3.74	4.5	8.8	14.8	10	very good	15,775

The tests show this rock to have medium hardness and resistance to wear, low toughness and very good cementing value. It has

also fairly high resistance to compression. Rocks of this nature do not as a rule give satisfaction in plain macadam road construction. It should, however, prove satisfactory in bituminous construction or with a bituminous binder and should make a good railroad ballast or concrete aggregate.

Granites are very prevalent in this county, but they have a number of disadvantages for use in road construction, arising from their low cementing value and low toughness. The disintegrated granites, however, are quite satisfactory when of the proper composition.

The only granite that has ever been crushed on a commercial scale is the red granite on the property of Darragh Bros. at Marble Falls, but the crushing has since been abandoned. This quarry is located about two miles northwest of Marble Falls on the Austin Northwestern Railroad. When this crusher was operating, the daily output of stone between 2½ inches and ¼ inch in size, was about three hundred tons per day.

A fine-grained pink granite has been listed by H. N. Banks, Florence, Texas. The material has never been produced, but it is close to the H. & T. C. Railroad spur, which branches off at Fairlands.

A number of disintegrated granite gravels have been used already in road construction, while others are so situated that they have possibilities. One disintegrated granite gravel is found on the property of Mr. J. J. Boyce, Burnet. It is located five miles west of Burnet on the Burnet & Bluffton Highway. Large quantity of this material is present, but no railroad exists at the present time.

Another granite gravel is composed of angular fragments of disintegrated granite and quartzite, a large proportion of which is below the ½″ size. This material is located at Marble Falls at Backbone Creek, about fifty yards southwest of the H. & T. C. Railroad depot on the property of F. M. Jones of Marble Falls. In 1916 there was produced about 15,000 tons, and the daily output is estimated at 1,000 tons. It has been used in Fort Worth, Hamlin, Marlin, Waco and in some culverts on the H. & T. C. Railroad as a concrete aggregate. The pit-run material is rather poorly graded, but if screened to correct sizes, should make a satisfactory concrete aggregate.

The Darragh Bros. of Marble Falls have a large deposit of disintegrated granite at Granite Mountain, about two miles northwest of Marble Falls on the A. & N. W. Railroad. This material is not being shipped at the present time, but could be easily loaded. The stones making up the gravel are small in size, so that the material is really a good sand-clay, which has proven a good material for the top course of a gravel road.

Several tests have been made on the disintegrated granite on the property of Darragh and Caterson of Granite Mountain, which are given below with the exact location of the materials:

MECHANICAL ANALYSIS

	No. 1	No. 2	No. 3
Material retained on 2-inch sieve	0	0	0
Material retained on 1-inch sieve	0	0	0
Material retained on ½-inch sieve	9.6	4.3	12.2
Material retained on ⅛-inch sieve	55.8	41.2	52.5
Material retained on .033-inch sieve	79.0	66.5	71.7
Material retained on .0116-inch sieve	89.0	76.5	80.0
Material retained on .0058-inch sieve	92.2	80.7	83.0
Material retained on .0029-inch sieve	93.8	82.8	84.5
Material passing the .0029-inch sieve	6.3	17.2	15.6
Total	100.1	100.0	100.1
Cementing value on:			
Material over ⅛ inch in size	Poor	Fair	Poor
Material under ⅛ inch in size	Good	Good	Good
Material as received	Fair	Fair	Fair

No. 1. Material from the south end of Horn Spur, from what is known as the S. C. Cockburn quarry at Granite Mountain. This gravel is composed of small fragments of a disintegrated granite, most of which is a sand and little clay. Should be satisfactory, but better material can be found in this locality.

No. 2. Pit northeast from Granite Mountain about 50 feet west of the Horn Spur of the H. & T. C. Railroad. This gravel is composed of more or less disintegrated fragments of granite and is properly considered as a sand. Should make a good sand-clay road or topping for a road with a foundation of coarser material.

No. 3. Pit to the east of Granite Mountain, about fifty feet east of the H. & T. C. Railroad track, and south of Granite Mountain station. This material should make a good sand-clay road or a top course on a foundation of coarse material.

Calhoun County

One deposit of material listed from this county is a mud shell taken from the San Antonio Bay and unloaded at Seadrift. The deposit is operated by W. D. Haden, Seadrift, Texas. The output is reported to be about 750 cubic yards per day. There are about thirty-five miles of roads surfaced in Calhoun County with this material.

Another deposit of this material is worked. It is located at Chicken-Roof, three miles from Port Lavaca and operated by the Smith Ullrich Dredging Company. During 1916 there were about 30,000 tons of the material produced and with present equipment it is possible to produce 400 tons a day. The Southern Pacific Railroad tracks are 800 feet from the docks and at the present time no switch exists. The material has been used on the Calhoun and Victoria County Roads and five miles of streets in the city of Port Lavaca. It is reported that Captain Nelson of the U. S. Corps of Engineers at Galveston says that this is the best shell on the Texas Coast.

Callahan County

The only material listed from this county is a gravel on the property of F. S. Bell, Baird, Callahan County. This material is close to the tracks of the T. & P. Railroad and three miles east of Baird. So far this material has not been developed, but it is reported that several railroad men have examined the deposit and have pronounced it as being good ballast material.

Chambers County

Located along both sides of the Trinity River at Wallisville is a deposit of clam shell. This material is produced by the Texas Rock Company of Beaumont. The material is loaded on barges and towed to Liberty, where it is loaded on cars of the T. & N. O. Railroad; or to Port Bolivar and loaded on the G. C. & S. F. Railroad; or taken to Houston and loaded on many of the railroads there.

Coleman County

One limestone on the property of H. J. Parker at the Santa Anna Mt., 400 yds. from the G. C. & S. F. Railroad, is the only material listed.

Collin County

A gravel tested from this county is given below together with its location and remarks resulting from the tests:

MECHANICAL ANALYSIS

	No. 1
Material retained on 2-inch sieve	0
Material retained on 1-inch sieve	15.8
Material retained on ½-inch sieve	25.6
Material retained on ⅛-inch sieve	44.7
Material retained on .033-inch sieve	61.5
Material retained on .0116-inch sieve	72.8
Material retained on .0058-inch sieve	72.6
Material retained on .0029-inch sieve	82.8
Material passing .0029-inch sieve	17.4
Total	100.2
Cementing value on:	
Material over ⅛ inch in size	Good
Material under ⅛ inch in size	Good
Material as received	Good

No. 1. This material was sent to the laboratory by E. O. Slaughter of Anna, Texas. It consists of rounded fragments of a hard flint and a soft limestone with considerable fine material of a calcareous nature. It is not recommended as a road material, being too soft, nor is it recommended as a concrete aggregate.

Colorado County

One characteristic of this county is the number of gravel pits, which are operated or are organized for commercial operation. This is due perhaps to the fact that this is about the first county from the coast that contains anything like a workable gravel combined wih the fact that in recent years there has been a large demand for road gravel in the coast country. There is, besides the worked deposits, a large number that have not been operated so far. Many of them are listed here.

One gravel, not worked, is located at Glidden within the switching limits of the G. H. & S. A. Railroad, on the property of E. J. Koche of Ellinger, Texas.

Another gravel, located near Eagle Lake, is composed of pebbles of quartz, jasper, agate, limestone, flint, chert, and granite. This material is reported to be located on the G. C. & S. F., the S. A. & A. P., and the G. H. & S. A. railroads.

A sand clay gravel is located on the property of J. W. Stafford, Columbus, Texas, 11 miles south of Columbus, 1 mile east of Altair, and one-half mile from the S. A. & A. P. Railroad. At the present time, there is no equipment on hand, but the owner reports that there are about 2,000,000 cu. yds. available. A small sample of this material on hand was composed approximately of 90 per cent of sand and clay. The pebbles are flint and quartz, with a good binder of red iron oxide clay. This material should make an excellent binder for a coarse gravel or on a foundation of other material.

On the property of W. Waldo, Union National Bank, Houston, Texas, is located a deposit of gravel composed of sand and silt and containing pebbles ranging in size up to 2 and 3 inches in size. A railroad is close to the deposit.

Three miles northwest of Columbus on the J. Tomlinson Survey, a gravel is located on the property of J. B. Grey of Columbus, Texas. The deposit, however, is located 1¼ miles from the railroad track and no material has ever been produced. A small sample on hand is composed of small flint and quartz pebbles with little clay.

A pit run gravel ranging from sand and silt to flint gravel 2 and 3 inches in size, is produced by Slavin & Cravin (J. W. Slavin, Thompsons, Texas, and M. M. Cravin, Mission City, Texas). The deposit is on the G. H. & S. A. Railroad and it is possible to load from 10 to 12 cars a day. This material is reported to be a good road material and has been used on the roads of Harris and Fort Bend counties.

The Altair Crushed Stone & Gravel Company of Columbus, Texas, has a gravel pit at Altair on the S. A. & A. P. Railroad which has not been worked. It is estimated, however, that there are approximately 6,000,000 cu. yds. available. The gravel is

composed of hard flint and quartz pebbles with some sand and red clay. A small sample on hand indicates that the gravel should make a satisfactory road gravel if the large stones above 2 inches in size were removed.

At Lakeside, southeast of Eagle Lake, is located a rather fine-grained gravel which is produced by the Eagle Lake Gravel Company (Howard Kenyon, Commercial Bank Bldg., Houston, Texas). During the last 6 months of 1916, there were produced about 39,000 tons, while the daily output is approximately 900 tons. A ¼ mile spur connects the deposit with the Cane Belt Railroad. The material has been used on the roads of Fort Bend, Harris and Wharton counties. The material is a good top course gravel, having about 70 per cent passing the ¾ inch sieve, with about 10 per cent sand and 15 per cent clay of good binding qualities.

A pit of gravel containing about 15 per cent of clay is located at Altair on the S. A. & A. P. Railroad, southeast of Eagle Lake, and is operated by the Trinity Sand and Gravel Company (J. P. McKinnis, Altair). The production has amounted to about 100 cu. yds. per day and has been used on the roads in the surrounding counties. The deposit is reported to extend for a mile on each side of the railroad and is 300 yds. wide and about 20 ft. deep. Tests have been made at the A. & M. College of Texas, but no report is on hand. A small sample on hand indicates that the gravel is composed of rounded pebbles of flint and quartz with some sand and clay. It appears to be a satisfactory road gravel.

The Texas Gravel and Sand Company of Houston, Texas, produces a washed and screened gravel at Ellinger on the La Grange Branch of the G. H. & S. A. Railroad. During 1916 this plant loaded out 50,000 cu. yds. of gravel. From a small sample on hand it appears that this is a well graded angular flint and quartz gravel free from sand or silt. It appears to be a satisfactory concrete aggregate, but is not recommended for use as a road building gravel without the addition of clay as a binder.

The only gravel tested from this county is that at the Haden pit at Glidden. The results of the test and the location and remarks are given below:

MECHANICAL ANALYSIS

	No. 1
Material retained on 2-inch sieve	0
Material retained on 1-inch sieve	10.2
Material retained on ½-inch sieve	27.2
Material retained on ⅛-inch sieve	51.4
Material retained on .083-inch sieve	68.2
Material retained on .0116-inch sieve	78.6
Material retained on .0058-inch sieve	81.5
Material retained on .0029-inch sieve	83.1
Material passing the .0029-inch sieve	16.9
Total	100.0
Cementing value on:	
Material over ⅛ inch in size	Poor
Material under ⅛ inch in size	Fair
Material as received	Poor

No. 1. Pit belonging to W. D. Haden, American National Ins. Bldg., Galveston, Texas. The pit at the present time is not being operated, however. There is a Marion Osgood steam shovel and a good 75 ton locomotive lying idle. The pit is on a spur of the G. H. & S. A. Railroad. Sample sent to laboratory by J. C. Baumgarten, Schulenburg. The fine material below the .0029″ sieve is mostly silica, only 3% of it being iron oxide clay and no calcareous material. This should make a fairly satisfactory road material.

A limestone near Altair on the S. A. & A. P. Railroad owned by the Altair Crushed Stone and Gravel Company is too soft for satisfactory road construction, but could be used satisfactorily for concrete aggregate.

A sandstone is reported to be in abundance near Altair on the S. A. & A. P. Railroad on the property of C. E. Grouce of Columbus, Texas.

Comal County

A number of samples was collected by the laboratory and tested. Most of the materials collected were gravel, as the limestone is as a rule rather soft and the gravel is so abundant that it seems reasonable to suppose that by far the greater proportion of material used will be gravel. The tests of the limestones with their locations are given below:

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.60	162	1.58	4.2	9.5	12.6	5	Poor	------
2	2.65	165	0.72	3.8	10.6	13.7	4	Fair	14,500
3	2.58	161	1.45	5.0	8.0	10.7	4	Fair	9,858
4	2.50	156	2.87	5.8	5.9	8.2	3	Fair	6,000
5	2.45	153	2.69	7.8	5.1	5.5	6	Fair	9,220
6	2.45	153	2.42	14.8	2.7	2.6	4	Good	3,445

No. 1. From Widow Rabe's place about five miles north of New Braunfels on old Government stage road, about 100 yds. from crossing of wagon road and M. K. & T. Railroad. Same ledge exists on the Kretzmaier property. This is a rather soft rock, with medium resistance to wear, low toughness, and poor cementing value. This material is recommended only for bituminous construction subject to medium or light traffic.

No. 2. This sample is from the property of the Dittlinger Lime Company of New Braunfels and is located 1 mile southwest of New Braunfels on the I. & G. N. and M. K. & T. railroads. The production is approximately 1,500 tons per day; the yearly production in 1916 amounted to 190,000 tons. The tests show this to be rather low in hardness with medium resistance to wear, low toughness, and fair cementing value. It has also fair resistance to compression. Recommended only for waterbound macadam roads subject to light traffic. If a bituminous binder is used it might be used on a little heavier traffic roads. This sample was taken from the best ledge of the quarry.

No. 3. Same location as above. This test is the average of 3 samples from the quarry. The test shows a soft rock, low in toughness, hardness and resistance to wear, only fair cementing value and low resistance to compression. It is not recommended as a road building material.

No. 4. This sample is from the property of the Comal Rock Co. of New Braunfels. It is a soft rock, low in toughness and resistance to compression. It is not recommended as a road building material.

No. 5. This sample is from the property of C. W. Ling of 725 So. Salado St., San Antonio, Texas. The material occurs 7 miles south of New Braunfels and 26 miles north of San Antonio on the I. & G. N. Railroad. This material was taken from the best ledge in the quarry. It is a soft rock, low in toughness and resistance to wear, with fair cementing value. It is rather low in compressive strength. It is not recommended as a road building material.

No. 6. The location is the same as above. The tests are the average of 4 samples taken from different parts of the quarry. The tests show this to be a very soft rock, having low resistance

to wear, low toughness, fairly good cementing value, and a very low resistance to compression. It is not recommended as a road building material.

Many samples from this county have been tested, most of which were limestone. Many of the gravels, however, had considerable flint pebbles in their make up. The tests of these gravels with their location and remarks are given below:

MECHANICAL ANALYSIS

	Per cent of material retained on:						Passing	Cementing Value on Material		
No.	2-in. sieve	1-in. sieve	½ in. sieve	⅛-in. sieve	.0116-in. sieve No. 48	.0029-in. sieve No. 200	.0029-in. sieve No. 200	above ⅛-in. sieve	below ⅛-in. sieve	as received
1	0	20.1	48.2	79.3	90.4	81.6	8.6	poor	poor	poor
2	1.2	12.9	42.1	75.4	91.3	94.5	5.5	poor	good	poor
3	4.6	14.1	36.0	74.5	90.4	92.7	7.1	poor	poor	poor
4	7.4	29.3	53.5	82.7	90.1	92.7	7.1	fair	poor	poor
5	0	26.2	60.6	82.8	89.2	90.7	9.2	poor	excell.	poor
6	7.4	22.2	51.8	82.3	90.7	97.3	3.0	poor	poor	poor
7	12.9	45.0	55.5	71.5	83.3	85.2	15.0	poor	excell.	good
8	5.1	28.7	52.3	60.0	87.0	91.2	9.1	poor	poor	poor
9	0	28.9	51.5	76.7	86.2	86.9	12.9	poor	excell.	fair
10	11.4	33.2	48.5	65.8	81.7	83.3	17.0	poor	good	poor
11	10.4	30.8	45.5	71.4	86.2	87.9	12.0	poor	excell.	poor
12	16.7	40.0	82.6	78.0	85.2	86.9	13.5	poor	excell.	excell.
13	19.7	57.0	75.2	86.0	89.4	90.1	10.0	poor	excell.	good
14	29.8	40.7	58.7	83.5	88.2	89.0	10.9	fair	fair	poor
15	2.5	20.5	41.8	73.0	82.3	84.1	16.0	poor	excell.	good
16	7.5	13.1	35.4	62.7	79.8	85.0	15.0	poor	fair	poor
17	5.2	26.3	49.1	74.0	82.5	84.4	15.8	fair	excell.	fair
18	0	44.7	70.1	96.4	97.9	98.0	1.5	poor	not made	poor
19	15.2	58.1	81.6	95.4	97.9	98.1	1.9	not made	not made	fair
20	30.0	72.8	85.0	91.2	93.8	93.9	5.9	fair	excell.	poor

No. 1. About 3¼ miles north of New Braunfels, Comal County, and about 500 yds. north of Gruene's store, on old stage road. This material should prove a very satisfactory road building material. It is composed of more or less rounded fragments of limestone.

No. 2. About 3 miles north of New Braunfels, Comal County, about 500 yds. southeast of Gruene's store. This gravel consists of rounded fragments of hard limestone. It should prove satisfactory as material for gravel road construction. Said to be good gravel.

No. 3. Reischter property, about 3 miles northeast of New Braunfels, on the San Marcos road, and I. & G. N. Railroad, and about 200 yds. north of San Antonio-Austin Road, Comal County. This gravel is composed of flat and rounded fragments of a fairly hard limestone with a small amount of fine calcareous material. It should prove satisfactory in gravel road construction.

No. 4. Mittendorf's place, about 6 mi. northeast of New Braunfels, and 100 yds. east of San Antonio-Austin Road, Comal County. This material consists of rounded fragments of limestone. It should prove satisfactory as a road building gravel.

No. 5. Near Hunter, on M. K. & T. Railroad, Comal County. This gravel consists of rounded fragments of hard limestone with little fine material. It should prove satisfactory as a road building gravel.

No. 6. Vacant lot on Castell Street, New Braunfels, Comal County, about ¾ miles southwest of county courthouse. This material is composed of flat and rounded fragments of limestone and some flint, and very fine calcareous material. Although lacking in fine material, it is believed that this gravel will make a satisfactory road building material.

No. 7. About 5 miles southwest of New Braunfels, on south side of Comal Creek and about ½ mile southwest of San Antonio-Austin Road. This gravel is composed of fragments of flint and some limestone with considerable fine calcareous material and clay. It should prove very satisfactory in gravel road construction.

No. 8. Adam Hubertos' place, prospect pit about 10 miles southwest of New Braunfels and about ¼ mile east of San Antonio-Austin Road, Comal County. This gravel consists of rounded fragments of limestone with considerable calcareous sand. It should make a fairly satisfactory road building gravel.

No. 9. Henry Soechting's place, about 1½ miles southwest of Hunter, and about 100 yards east of San Antonio-Austin Road, Comal County. This material should prove satisfactory as a road building gravel. It is composed of rounded fragments of flint and limestone with considerable very fine calcareous material.

No. 10. About 7½ miles southwest of New Braunfels, and about 75 yards northwest of San Antonio-Austin Road, in lane, Comal County. This gravel consists of rounded fragments of limestone with considerable very fine calcareous material. Although this material contains a good deal of fine dust it is recommended as a road building material.

No. 11. About 1½ miles southwest of I. & G. N. railroad depot at Hunter, and about 50 yards below bridge over York Creek, near San Antonio-Austin Road, Comal County. This material consists essentially of fragments of limestone with some chert and shells, well graded. It should prove very satisfactory as a road building gravel.

No. 12. About 5 miles southwest of New Braunfels, on Comal Creek, and about ½ mile northwest of San Antonio-Austin Road, on north bank of creek. This gravel is composed of rounded fragments of flint and chert with considerable clay and fine calcareous material. It should make a very satisfactory road material, provided the stones above 2″ in size are removed.

No. 13. Southwest of New Braunfels, about 4 miles on Comal

Creek above road crossing, about ¾ mile northwest of P. Schumann's blacksmith shop on San Antonio-Austin Road, Comal County. This gravel is composed of more or less rounded fragments of a very hard flint with considerable plastic clay. It should make a very satisfactory gravel road.

No. 14. Ernstein pit, about 1½ miles east of New Braunfels, on Seguin Road, about ¼ mile from San Antonio-Austin Road, Comal County. This gravel is composed of rounded fragments of limestone with considerable very fine calcareous material. If the large stones over 2″ in size are screened out, this material should prove satisfactory in gravel road construction.

No. 15. Near Hunter, Comal County, on M. K. & T. Railroad. This gravel consists of rounded fragments of flint and limestone with considerable fine material of a calcareous nature. It should prove satisfactory as a road building gravel.

No. 16. About 4 miles west of New Braunfels, on I. & G. N. Railroad and about 1 mile northwest of San Antonio-Austin Road, Comal County. Sample sent in by Dittlinger Lime Co., New Braunfels, Texas. This gravel is composed of fragments of a rather soft limestone with considerable fine material. It is recommended only for light traffic gravel road construction.

No. 17. About ¾ mile southwest of Hunter, on bank of York Creek at culvert of Otto Preusse, Comal County. This gravel consists of rounded fragments of limestone, fairly hard, with a considerable amount of very fine calcareous material. It should prove a satisfactory road building material.

No. 18. Specht property, York's Creek, about 300 yards west of Hunter, Comal County. This gravel consists of large angular fragments of limestone with practically no fine material. Material above 2″ was screened out before the mechanical analysis was made. It is not satisfactory as a road building material: however, this gravel would prove a very good concrete aggregate or road ballast.

No. 19. About 1 mile southwest of Hunter on San Antonio-Austin Road, at crossing of York's Creek, Comal County. This gravel consists of rounded fragments of limestone free from sand or clay. It is recommended for road building, and should make a good concrete aggregate.

No. 20. About 5 miles northwest of New Braunfels, on Alligator Creek, pit about 200 yards up creek from San Antonio-Austin Road, Comal County, on W. Hausmann's place. This gravel consists of large rounded fragments of rounded limestone fragments with little sand or clay. It does not contain enough sand or clay to be satisfactory as a road material.

Cooke County

F. W. Williams of Myra, Texas, owns a sand clay gravel pit, ½ mile southwest of Myra and ½ mile from the M. K. & T. Railroad. The deposit covers considerable territory and is from 5½ to 13 feet in depth.

At Lindsay, 5½ miles west of Gainesville is located a large pit operated by the Gainesville Gravel Co. (McDaniel Bros. of Gainesville working the plant.) The plant is on a spur of the M. K. & T. Railroad and at the present time the equipment consists of two steam shovels and a drag line excavator, which permits a daily output of 3,000 yds. The material has been used on the roads of Cooke, Fannin and Grayson counties. A small sample on hand indicates that the gravel is composed of hard and soft limestone pebbles and some concretionary material. The sample apparently has been washed and screened as a concrete aggregate.

Coryell County

One sample of limestone from this county has been tested and the results are as follows:

Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
2.50	156	3.94	12.5	3.2	6.0	2	Excell.	6,250

This material comes from the property of D. R. Boon, Oglesby, Texas. This is a very soft limestone, with low resistance to wear, very low toughness, excellent cementing value, and low resistance to compression. It is much too soft to make a satisfactory road building material.

Culberson County

Like Brewster County, this county has a large assortment of rock most of which is quite suitable for road construction. However, it is located in a region where, at the present time, there is little need for good roads other than a few through and military roads, perhaps. In the Van Horn Mountains can be found

diabase, basalt and andesite, but the nearest shipping point is the Southern Pacific Railroad. A large outcropping of diabase is located 5 to 6 miles southwest of Van Horn. It is distinctly massive, greenish black, dense, and very fine-grained. In some places, it is as much as 100 ft. thick.

In the Wylie Mountains south and east of the Wylie ranch house are found outcroppings of granite, andesite, and basalt. The closest shipping point, however, is Lobe on the Southern Pacific Railroad. Some granites and crystalline schists are located in ravines west of the Van Horn wells and about 2 or 3 miles west of the Southern Pacific Railroad.

Vesicular lavas are found in the mountains between Chispa and the Wylie Mountains with the closest shipping point at Chispa or Arne on the Southern Pacific.

Heavy beds of limestone and sandstone are found in several places in this county. At Guadalupe Point and 3 miles south of this point, at Horseshoe Draw, Rustler Hills and the Hague Trail in the Delaware Mountains, 18 miles south of the Guadalupe Mountains, will be found the outcroppings.

Dallas County

There is quite a large number of gravel deposits in this county and many of them are worked on a commercial scale.

The J. Fred Smith Gravel Co. operates a number of gravel pits in this county at Carrollton on the St. L. & S. W. Railroad, Trinity Mills and Letot on the M. K. & T. Raliroad, and Gribble on the St. L. & S. W. Railroad, all northwest of Dallas. During 1916, this company produced about 560,000 tons of gravel and with the present equipment, the company estimates that they can produce 8,000 tons per day. Much of this gravel is for concrete, but the road gravel has been used on the roads of Collin, Dallas, Ellis, Fannin, Grayson, and Hunt counties. No tests have been made on the road gravel, but a rather complete test has been made showing this to be a satisfactory concrete gravel when properly proportioned.

The McLean Sand and Gravel Co. operates a gravel pit at Carrollton on the St. L. & S. W. Railroad, but it is believed that

this company makes a specialty of washed gravel for concrete. This concrete gravel has been tested in the laboratory with rather good results.

The Clem Gravel Company of Dallas operates a gravel plant at Trinity Mills just northwest of Carrollton, on the M. K. & T. Railroad. This company likewise specializes on concrete gravel. During 1916, there were 130,000 tons produced, or about 1,500 tons daily. The gravel is composed of washed pebbles of limestone with a certain amount of concretionary material. There are no records of this material having been tested as a road material, but several tests have been made on this material as a concrete aggregate at the Pittsburg Testing Laboratory, by the City of Dallas and by the University of Texas Testing Laboratory. All of these tests show that the material is satisfactory as a concrete aggregate.

The Grand Prairie Gravel Co. (Velbig Bros.) of Dallas operates a gravel plant at Grand Prairie on the T. & P. Railroad. During 1916 there was produced approximately 102,000 yards and with the present equipment, it is estimated that there can be produced 65 car loads per day. The gravel has been used in Dallas County and in Forney and Terrell and as ballast for the T. & P. Railroad.

On the west side of the Trinity River, between Dallas and Oak Cliff, is a deposit of gravel which is used chiefly for concrete. The property is on the Santa Fe Railroad and owned by C. M. Miller of Dallas. The gravel has been used on the streets of Dallas and Oak Cliff and also by the Terminal Company of Dallas.

A deposit of gravel is located on the property of C. H. Bussey of Hutchins, Texas, 1 ½ miles east of the H. & T. C. Railroad at Hutchins. Negotiations are under way for a spur track to the pit.

About 1½ miles north of Grand Prairie on the B. S. Reed Survey is located a gravel deposit belonging to C. M. Means and L. W. Means of Grand Prairie. The switch off the Texas and Pacific, which runs to the Grand Prairie Gravel Co., is the closest shipping point as this gravel company adjoins the latter property. It is reported that there can be supplied either concrete or road gravel from this deposit.

Three miles south of Garland, a gravel deposit is located on the property of R. Schafer of Mesquite, Texas, R. F. D. No. 3. About 700 yds. were used in 1916. The deposit, however, includes about ½ acre and is from 6 to 12 inches deep. A small sample on hand is composed of limestone pebbles most of which are below ¾ in. in size and free from dust and clay.

A deposit of sand is located at Carrollton on the property of D. D. Duncan, Carrollton. A spur track exists near the pit and the gravel is loaded from wagons.

Another deposit of sand is located 2½ miles southeast of Dallas on the Kaufman Pike and about 1,500 ft. from the T. & N. O. Railroad on the property of H. A. Buchanan, 146 W. Magnolia St., Fort Worth, Texas.

A report of W. S. McGregor of Temple, Texas, gives the location of two gravel deposits from this county. One pit is located 3 miles west of Dallas near Cement City on the T. & P. Railroad and is operated by the Trinity-Strong Gravel Co. (W. T. Strong, Dallas). The deposit covers about 50 acres and contains about 400,000 cu. yds. of road gravel with iron oxide clay binder and about 250,000 cu. yds. of concrete gravel.

Another deposit is located 4 miles south of Carrollton on the Rock Island Railroad and contains about 2,500,000 cu. yds. of good concrete gravel with trackage. The owner is S. B. Scott, Scollard Bldg., Dallas, Texas.

Two samples of limestone from this county have been tested, but neither one of them could be considered as a satisfactory material for road construction. Below are given the results of tests.

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.00	124	14.1	10.0	4	0	2	Excell.	3,200
2	1.90	118	17.5	23.4	1.7	0	1	Good	1,575

No. 1. This limestone is found on the property of F. J. Shutt, Duncanville, Texas. It is a very soft limestone, with very low toughness and resistance to wear, but excellent cementing value. It has a very low resistance to compression. This stone is not satisfactory for road construction.

No. 2. This material is in the same locality as that above. It is a very soft limestone, with low toughness and resistance to wear, and good cementing value. It has very low resistance to compression. This stone is not satisfactory for road construction.

Deaf Smith County

There is little road material of any description in this county, but the need for good material in this locality is not great and the natural conditions tend to preserve the natural earth roads in good condition if the traffic is not too heavy.

One sample of caliche is the only material tested from this county. The tests on this material follow:

Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
2.65	159	3.30	17.8	2.2	----------	5	Excell.	9,650

This material is a caliche limestone from the Hadden Estate, Herford, Texas. There are approximately 800,000 cu. yds. exposed. The rock has low resistance to wear and toughness, excellent cementing value, and low resistance to compression. This rock is not recommended as a road building material. Caliche of this nature has been used to a considerable extent in road construction, but the roads are dusty in dry weather and develop ruts in wet weather.

Denton County

Several samples have been tested from this county besides two that have been listed without tests.

Four miles southwest of Sanger on the Santa Fe Railroad is located a gravel deposit belonging to Fred Hopkins of Sanger, Texas.

William Whitfield of Justin, Texas, owns a deposit of soft limestone gravel with considerable fine calcareous sand. It is located 1½ miles east of the G. C. & S. F. Railroad and 6 miles west of the M. K. & T. Railroad on the Justin-Argyle Road. The pit is not worked at the present time. It is estimated that there are about 65,000 cu. yds. of the material available. A small

sample on hand indicates that the material would pack well and be satisfactory for light traffic, but under heavy traffic it would not be satisfactory.

Below are given a number of gravels from this county, together with their locations and remarks:

MECHANICAL ANALYSIS

	No. 1	No. 2	No. 3	No. 4
Material retained on the 2-inch sieve	0	4.1	2.1	0
Material retained on the 1-inch sieve	20.6	45.7	16.7	0
Material retained on the ½-inch sieve	52.3	85.7	29.5	7.1
Material retained on the ¼-inch sieve	77.4	99.2	60.9	45.3
Material retained on the .033-inch sieve	88.9	100.0	73.7	67.6
Material retained on the .0116-inch sieve	95.8	-----	75.9	69.2
Material retained on the .0058-inch sieve	97.8	-----	80.6	72 2
Material retained on the .0029-inch sieve	98.7	-----	84.2	73.5
Material passing the .0029-inch sieve	1.3	-----	15.8	26.4
Total	100.0	-----	100.0	99.9
Cementing value on:				
Material over ⅛ inch in size	Poor	Fair	Fair	Fair
Material under ⅛ inch in size	Excell.	Excell.	Excell.	Excell.
Material as received	Poor	Fair	Excell.	Good

No. 1. On the property of R. T. Yearby, about 3 miles southwest of Denton, and about ¼ mile west of the M. K. & T. Railroad. This material is composed of somewhat soft limestone with little clay. It should prove satisfactory for gravel roads having a medium traffic.

No. 2. About 5½ miles west of Denton, on the main Decatur and Denton wagon road on the property of G. B. Eagen. The gravel is composed of large, flat fragments of limestone with no sand or clay. This material is recommended for the foundation course, or if used in the top course, it should have about 30% of sand and clay mixed with it so that it will set into a compact impervious surface.

No. 3. From about 2½ miles south of Denton and about 50 yards west of the M. K. & T. Railroad. This gravel is composed of fragments of sandstone, some very soft disintegrated limestone and a considerable amount of fine calcareous material and clay. Due to the large amount of extremely soft material composing this gravel, it is not recommended except for very light traffic.

No. 4. From the property of C. B. Grant, 3.1 miles southwest of Denton and ½ mile west on the M. K. & T. Railroad. This gravel is composed of soft fragments of disintegrated chert, with a considerable amount of red oxide of iron clay. It is recommended only as a binder for roads lacking binding material such as a gravel in which clay and sand are absent.

The results of tests of two samples of limestone from this county are given below:

No.	Sp Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.55	159	2.86	4.2	9.5	13.4	4	Good	13,850
2	2.60	162	2.28	5.0	7.9	14.2	5	Fair	15,000

No. 1. A small exposure of limestone 3½ miles southwest of Denton and about ¼ mile west of the M. K. & T. Railroad. This rock has low hardness and toughness, medium resistance to wear, good cementing value and fair resistance to compression. This material is recommended for roads having light traffic only.

No. 2. This limestone was taken from the property of Jack Pass, about 5 miles north of Denison and 3 miles west of the M. K. & T. Railroad. This is a medium hard rock with low resistance to wear and toughness, fair cementing value and resistance to compression. This material should prove satisfactory for medium traffic water-bound macadam or bituminous roads. It is a good material for railroad ballast or concrete aggregate.

DeWitt County

A number of deposits of sand and gravel from this county are listed, but not any rock, as there is very little of the latter exposed.

Directly north of the Southern Pacific Railroad, 1 mile south of Thomaston on the G. H. & S. A. branch, a deposit of gravel is located on the property of the Thomaston Sand and Gravel Co. of Corpus Christi, Texas. It is reported that it covers 45 acres. The gravel ranges from 3 in. down, while the sand is coarse and sharp and composes about 38 per cent of the material. Besides this there are about 60 acres of clay and gravel mixed, suitable for road material.

A deposit of gravel is located ¾ mi. northeast of Thomaston and ½ mi. east of the Southern Pacific Railroad on the property of J. H. Pridgen, Sr., Thomaston, Texas. A hill intervenes between the deposit and the railroad, so that the deposit has never been worked. It is reported that the railroad has made

tests of this material and has recommended it as being good material, but no report is on hand.

A deposit of road gravel is located two miles south of Thomaston on the G. H. & S. A. Railroad on the property of J. S. McCrabb, Thomaston, Texas. The material has been used on the Wharton County roads, but the switch has been taken up.

Chas. D. Peary of Cuero, Texas, owns a deposit of gravel at Cuero, on the G. H. & S. A. and the S. A. & A. P. railroads, which has been used on the DeWitt and Wharton County roads.

Two samples of gravel from Yoakum were tested by the Office of Public Roads at Washington, and are given here with their recommendations.

MECHANICAL ANALYSIS

	No. 1	No. 2
Material retained on 2-inch sieve	24.0	22.7
Material retained on 1-inch sieve	50.0	47.6
Material retained on ½-inch sieve	68.0	71.2
Material retained on ⅛-inch sieve	83.0	84.8
Material retained on .033-inch sieve	93.1	90.9
Material retained on .0116-inch sieve		
Material retained on .0058-inch sieve	99.6	98.4
Material retained on .0029-inch sieve	99.9	99.4
Material passing the .0029-inch sieve	0.1	0.6
Total	100.0	100.0
Cementing value on:		
Material over ⅛ inch in size	Low	Low
Material under ⅛ inch in size	Excell.	Excell.
Material as received	Fair	Good

No. 1. This sample was sent to the laboratory by J. W. Benjamin, County Engineer, and the location is Yoakum. The sample consists essentially of large rounded fragments of chert and quartzite with some quartz and ferruginous clay. The percentage of material passing the ⅛-inch screen and the percentage of clay material (passing the 200 mesh sieve) are too small for satisfactory use in ordinary gravel road construction. This could be corrected by adding about 15% of a mixture of sand and clay to the gravel.

No. 2. This test was made at the request of Mr. J. W. Benjamin, County Engineer. The material is from Yoakum, DeWitt County. The sample consists essentially of large rounded fragments of chert, quartzite and sandstone with some quartz sand and very little clay. The percentage of clay material passing the ⅛-inch screen and the percentage of clay material (passing No. 200 sieve), are too small for satisfactory use in ordinary gravel construction.

This could be corrected by adding about 15% of a mixture of sand and clay to the gravel.

Dimmit County

Gravel is found on the high ridges 29 miles east of Eagle Pass on the Eagle Pass-Carrizo Springs road.

Duval County

The Sherman Concrete Company has a deposit of limestone 2 miles east of Benavides near the Texas Mexican Railroad tracks with a switch running to the quarry from the main line. With the present equipment and a few repairs, the plant can produce about 100 tons per day. This material has been tested in the laboratory of the Warren Bros. in Cambridge, Mass., but no report is on hand.

The Sherman Concrete Co. of Corpus Christi also owns a deposit of hard sandstone at Noledo. During 1916, this quarry produced 15,000 tons of stone. This material is located near the tracks of the Texas Mexican Railroad and has been used in the concrete for the streets of Corpus Christi.

Besides these there is a large quantity of white earthy limestone near Hebbronville, Realitos, northwest of San Diego, but it is doubted if any of these deposits could be used for road construction. Some white limestone is also found along the Tildon road about 12 or 13 miles northwest of San Diego.

Eastland County

This county lies in the belt of the hard limestone running from the north to the south through the State. Two tests have been made of limestones from this county and are given in the following tables:

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.55	159	2.62	4.2	9.6	10.5	5	Good	11,350
2	2.60	162	1.99	not enough material		11.3	4	-------	12,325

No. 1. This sample is from the quarry of the Tiffin Crushed Stone Co., Ranger, Texas. The tests show this to be a soft rock, low in toughness and resistance to wear, good cementing value and fair resistance to compression. This rock is recommended only for waterbound macadam roads subject to light traffic. Could be used successfully under slightly heavier traffic with a bituminous binder.

No. 2. This limestone is from the Rogers Quarry and the tests were made at the request of the Engineering Department of the T. & P. Railroad. This is a soft rock, low in toughness and with fair resistance to compression. Insufficient tests were made to warrant a recommendation on this material.

Edwards County

No tests have been made of material from this county, but the predominating material is gravel which is found in the drainage basins of the tributaries of the West Nueces River, especially Sycamore, Dry Sycamore, and Hackberry creeks. This gravel is mostly flint and limestone gravel.

Ellis County

A gravel deposit is located 3 mi. southeast of Waxahachie and ¼ mi. from the T. & B. V. Railroad on the property of G. W. Marshall of Waxahachie, Texas. The T. & B. V. Railroad is ¼ mi. from the pit, but there would be little trouble to run a spur to the pit. At the present time there is no loading equipment at the pit. It has been used on the Ellis County roads and as railroad ballast for the T. & B. V. Railroad.

Another deposit of gravel is located on the property of John Clouch of Maypearl, 500 yds. south of the I. & G. N. Railroad and less than ½ mi. southwest of Maypearl. The gravel from this property has not been used, but that from the adjoining property has been used on the Ellis County roads.

El Paso County, (Including Hudspeth County)

Like many of the western counties, El Paso County is abundantly supplied with good road building materials, but with the

exception of the country immediately contiguous to the city of El Paso, there is little demand for the higher type of roads.

In the southern Carrizo Mountains between the Texas and Pacific Railroad and the Southern Pacific Railroad, just west of the Culberson County line, is located a great variety of rocks. These are reddish, grey, and greenish schists with numerous intrusive quartz dikes, also granites, limestone and a great deal of gravel. In the Franklin Mountains there are small masses of diabase (trap rock) varying in thickness from a few inches to about 25 feet. Basalt and strongly metamorphosed limestone are located in the Cox Mountains about one mile due west of the end of the limestone cliffs of the Sierra Diablo, 12. mi. north-northwest of Eagle Flat and east-northeast of Sierra Blanca. Numerous outcroppings of granite occur in this county. Several detached areas are located at the base of the Franklin Mountains. They usually form the lowermost outcrop above the slopes at the base of the range and extend upward from a few feet to about one thousand feet. At one place only, at the pass immediately north of the highest peak, the granite crosses the crest of the mountain in a narrow belt and is exposed on the western slope. The main outcrop occupies an irregular area about four miles long varying in width from a few feet to a little more than a mile at the northeastern base of the range. The common type is red in color and medium to coarse-grained, composed of quartz, feldspar, and a small amount of biotite mica and hornblende. The last two minerals weather to chlorite. Northwest of Fort Bliss and along the eastern base of the central part of the range a porphyritic type is developed, consisting of crystals of red and grey feldspar up to 4 in. in width, in a granular base. Another deposit of granite of great strength and durability is located in the Hueco Mountains at Cerro Alto near the New Mexico line. A strongly micaceous granite breaks through schists in a spur of the Van Horn Mountains about 10 mi. south of Bass Canyon and 6 mi. south of south bend in the Southern Pacific Railroad near Mica Tanks. The northern side of the Quitman Mountains is composed of granite with porphyritic intrusions. The northeastern part of the western and main mountain ridges is granite to about 1 mi. east of the Bonanza

mine. There the rocks change to porphyries with augite and basalts with intercalations and intrusives of greenstone porphyries. These continue as far south as the Quitman Pass. The porphyries are solid and massive, the fractures uneven and hard and more tough than brittle. Granites and rhyolites are found also in the Sierra Blanca.

On the low hill southeast of the T. & P. Railroad pump station in the Carrizo Mountains is an outcropping of rhyolite, the surface of which is greatly weathered, but fresh exposures show dense fine-grained greyish to reddish rock composed of small phenocrysts of quartz, orthoclase and albite in a ground mass of minute gray grains of interlocked quartz and feldspar.

Falls County

Mr. W. P. Sloane reports that there is a large quantity of gravel within ½ mile of the I. & G. N. spur and 1½ mi. northwest of Marlin and 1 mi. from the H. & T. C. Railroad. Part of this deposit belongs to him and he reports that it is all good road-building gravel, packing without difficulty under traffic.

Fannin County

Twelve miles northwest of Bonham, and 16 mi. southeast of Denison, Mr. S. A. Vaughn of Saxony, Texas, owns a deposit of rock. It is located 1 mi. from the railroad, however, and 1½ mi. from the switch. Several tests have been made on sandstones from this county and the results of these tests are given below:

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.65	165	0.86	3.1	13.0	17.1	6	very good	15,000
2	2.57	160	2.15	7.1	5.64	14	2.5	very good	7,575
3	2.64	165	.965	9.6	4.17	----------	---------	--------	10,800

No. 1. From the property of Mr. D. P. Warren, 14 miles north of Bonham and made at the request of Geo. A. McClellan, Engineer. The tests show this to be a calcareous sandstone. This rock is hard, with medium resistance to compression. This stone should prove satisfactory for light traffic, plain macadam road or moderate traffic, bituminous construction. This rock is a little better than the average rock used in road-building in Texas.

No. 2. From the quarry of Hicks & Fitzgerald, located at Savoy, Texas. This is a mouse-colored sandstone with medium hardness and low resistance to wear and compression.

No. 3. From the quarry of Hicks & Fitzgerald, located at Savoy, Texas. This is a shell-incrusted, mouse-colored shell sandstone, with low resistance to wear and fair resistance to compression.

Fayette County

This county is somewhat different from the average, from the fact that not only gravel and limestone are found in the county, but also a sandstone. This latter, however, is generally somewhat soft, the grains being rather loosely cemented together. The limestone is not particularly hard or tough, and as a rule has little to recommend it for road construction. The gravel, however, can be found satisfactory in quality and quantity for road construction.

One deposit belonging to W. P. Colin, Port Neches, Texas, is located 1,000 ft. from the Southern Pacific Railroad near Ellinger, Texas. A pit of flint-gravel already opened, belonging to W. Waldo of Houston, Texas, is located on a spur of the Southern Pacific Railroad. The M. K. & T. Railroad is about 1½ mi. distant. This material has been used on the Harris County highways and as ballast on the Southern Pacific Railroad. It is located at Duise, Fayette County, and is reported as having enough equipment at present to load 12 cars daily.

The McLelland Gravel Company of Houston, Texas, operates a pit of clay and gravel on a spur of the La Grange branch of the G. H. & S. A. Railroad. This deposit is located about 1,000 ft. north of this railroad, and 4 mi. southwest of Fayetteville. The gravel is made up of pebbles of flint and quartz, though the greater proportion is quartz-sand with some red oxide of iron clay. It is estimated that the deposit contains about 1,000,000 yards. It has been used in several counties in south Texas.

The La Grange Gravel Company of La Grange, Texas, owns a

deposit of gravel within ½ mi. of the M. K. & T. Railroad near La Grange.

Another deposit of gravel is located 1 mi. south of La Grange on a switch just off the main line of the M. K. & T. Railroad. The deposit is owned by O. Moellenberndt of La Grange, Texas, who reports that the material has been used on county roads in Fayette County, and also by the M. K. & T. Railroad as ballast. A small sample on hand shows this gravel to be really a sand mixed with red oxide of iron clay having practically no large pebbles.

The Houston Electric Company of Houston, Texas, owns a gravel pit at Fayetteville, on the M. K. & T. Railroad. The material is a pit-run gravel ranging in size from silt to flint gravel pebbles, from 2 to 3 in. in diameter. It is reported that this is an exceptionally good road material and railroad ballast, and it has been used in city streets, county roads, and in ballasting street-car tracks.

On the M. K. & T. Railroad in this county, Mr. John H. Wessels of Halsted, Texas, operates a pit at Halsted and one at Wessels. These are pit-run gravels, ranging from silt and sand to flint pebbles, from 3 to 4 in. in diameter. The material has been used on various roads and is reported to be a fair road-building gravel provided pains are taken to secure the best in the pits. However, if this is not done, the poor road material is apt to be obtained. Two gravels from this county were tested as follows:

MECHANICAL ANALYSIS

	No. 1	No. 2
Material retained on 2-inch sieve	0	0
Material retained on 1-inch sieve	5.3	7.4
Material retained on ½-inch sieve	16.8	15.9
Material retained on ⅛-inch sieve	51.2	39.1
Material retained on .033-inch sieve	68.0	62.2
Material retained on .0116-inch sieve	82.7	77.1
Material retained on .0058-inch sieve	84.6	79.1
Material retained on .0029-inch sieve	85.6	80.1
Material passingg .0029-inch sieve	14.6	20.1
Total	100.2	100.2
Cementing value on:		
Material over ⅛ inch in size	Not made	Not made
Material under ⅛ inch in size	Fair	Good
Material as received	Fair	Fair

No. 1. This gravel is taken from city property at La Grange, Texas. The sample was sent in by J. C. Baumgarten, President Schulenberg Highway League. It contains more or less rounded fragments of quartz and flint with considerable sand and good binding ferruginous clay. It will pack down and bind well in a road, but it will require more maintenance than a gravel containing a larger proportion of stones between ¼ inch and 1½ inches in size.

No. 2. This gravel is taken from the Loessin pit, adjoining the La Grange city pit. The sample was sent by J. C. Baumgarten, Pres., Schulenberg Highway League. It consists of more or less rounded fragments of flint and quartzite with considerable sand of the same nature and a good binding clay. It will pack and bind well in a road, but will need considerable maintenance, due to the large proportion of sand it contains. It is recommended as a binder course upon a foundation of coarser gravel.

Three samples of limestone in this county have been tested with the following results:

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.25	140	3.81	11.5	3.5	17.7	9	Good	15,325
2	2.65	165	1.56	6.9	5.8	9.7	2	Good	----------
3	2.50	156	4.08	----------	----------	----------	3	Excel.	5,617

No. 1. This sample of limestone is from the property of Louis Reineseck, at Buckner's Creek, 3½ miles northwest of La Grange. The sample was sent by J. C. Melcher, O'Quinn, Texas. This material has from 4 to 10 ft. exposure. It is a medium hard rock, with very low resistance to wear, low toughness and good cementing value. It has fairly high resistance to compression. The rock is not homogeneous, the hard part being a good road material, while the soft material is poor; therefore, as a whole, the sample would not be recommended.

No. 2. This limestone was found near O'Quinn, Texas. It was sent in by J. C. Melcher, O'Quinn, Texas, and labeled "Alabaster". The tests show that this is a soft rock, with low resistance to wear and toughness and with good cementing value. Not recommended as a road building material.

No. 3. This sample of limestone is from the property of Frank Hansen, located at Buckner's Creek, 4 miles west of LaGrange. It was sent in by J. C. Melcher, O'Quinn, Texas. The tests show that this material has 30-ft. exposure, and is a soft rock with very low toughness and excellent cementing value. Not recommended as a

road building material. There was not enough of sample for abrasion test.

The sandstone of the county is semi-quartzitic sandstone and runs in a belt through the county in very variable condition, some of it being hard while, within close proximity, it is considerably disintegrated. At a point 3½ miles south of West Point at the crossing of the S. A. & A. P. Railroad over Jack John Creek, is an outcropping of this semi-quartzitic sandstone about 15 ft. thick. Another deposit is found 1½ miles northwest of La Grange in the bluffs of the Colorado River, near the M. K. & T. Railroad. It is about 30 ft. thick and rather hard. East of La Grange 2¼ miles on the La Grange-Columbus Road, is another deposit of sandstone from 20 to 25 ft. thick. Still another is found on top of the hill 1 mile west of Plum. Two miles northeast of Ledbetter on a branch of Turkey Creek is located a gray sandstone 4 to 5 ft. thick, which is used locally for building purposes. Within the town of Muldoon and about 1 mile south of the postoffice and 600 yds. from the S. A. & A. P. Railroad there is a deposit of sandstone owned by J .E. McAnally of Beaumont, Texas. A switch of the S. A. & A. P. Railroad is located 200 yds. east of the deposit. It covers approximately 10 acres, but has never been used commercially, though it is reported that some of the material in the adjoining property has been used in the construction of sea-jettics. Tests have been made on two other sandstones in this county, as follows:

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	Freneh coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.15	134	7.64	4.1	9.7	17.8	11	Fair	14,075
2	2.05	128	7.89	6.3	6.4	0	5	Excel.	7,270

No. 1. This sample was found near Lena Spur, S. A. & A. P. Railroad. The sandstone was sent in by J. C. Melcher, O'Quinn, Texas. The tests show that this is a hard rock, with medium resistance to wear, rather low toughness, fair cementing value, and also fair resistance to compression. This material should prove very satisfactory in bituminous macadam roads, but should not be

used in water bound macadam. It makes good railroad ballast or concrete aggregate.

No. 2. This sandstone was found near Lena Spur, with low resistance to wear and toughness and excellent cementing value. It has low resistance to compression. This material is not recommended as a road building material.

Frio County

Along the I. & G. N. Railroad 2½ miles north of Pearsall and on the west side of the railroad, is a deposit of gravel belonging to N. W. Ware. This material has been used by the I. & G. N. Railroad for ballast. The county clerk of Frio County reports that there are great quantities of gravel north of this pit.

Gillespie County

In the bed of the Pedernales River, there is considerable gravel to be found. One deposit, used on the Austin-Fredericksburg Road near Stonewall, is to be found on the Morris Ranch. The marble from this county has been tested as a road material as follows:

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.70	168	0.29	4.5	8.9	15.2	4	0	----------

No. 1. This marble was found at Cherry Springs, unoperated quarry, 35 miles south of Llano, near the Mason County line. The tests show that this rock has medium hardness and resistance to wear, and low toughness. It is not recommended for water-bound construction, but should be satisfactory for medium traffic bituminous roads.

Gonzales County

Among other things, this county has a deposit of fairly hard gray sandstone. One deposit is located 4½ miles southeast of Pilgrim in the bluffs of Cattlemen's Fork. This deposit is approximately 10 ft. thick, and is located on the G. H. & S. A.

Railroad. This same material is found in layers 30 to 40 ft. thick, 4½ miles east of Smiley, forming bluffs on the creek. It also forms a hill 4 miles south-southwest of Pilgrim, which is also on the G. H. & S. A. Railroad.

Grayson County

Just west of Denison, and 1,000 ft. from the switch, is a limestone quarry, belonging to E. F. Bush of Denison, Texas. This material, it is reported, has been used on some roads in Grayson County, and the quarry has an output of from 50 to 70 cu. yds. per day. Tests have been made by the U. S. Office of Public Roads at Washington, but no record is on hand.

The North Texas Sand and Gravel Company of Ambrose, Texas, produces a concrete sand, which has been used in the concrete roads of Hunt County. The deposit is located a short distance south of Ambrose on a spur of the M. K. & T. Railroad. In 1916, there were 40,000 tons produced. The material is a quartz and flint sand stained with iron oxide, rather medium fine in grading. W. A. Thornton, Route 5, Denison, Texas, owns a deposit of sand 5 miles north of West Denison, but 3 miles from the railroad. A small sample on hand shows this to be medium fine graded sand with some larger pebbles of flint and quartz. A ferruginous sandstone in this county has been tested as follows:

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.95	184	1.67	3.1	13.1	19.3	14	Fair	20,700

No. 1. Sample sent to the Laboratory by Wm. Veich, Denison, Grayson County, Texas. The tests on this stone show it to be a hard rock, with medium toughness and resistance to wear, fair cementing value and high resistance to compression. This should make a very satisfactory material for road construction, especially when used with a bituminous binder. It should make a good concrete road aggregate or railroad ballast.

GRIMES COUNTY

This county lies in a belt of quartzitic sandstone, but there is also located in the county considerable gravel and some softer grades of limestone. W. J. Callahan of Shiro, Texas, has a gravel deposit in charge. The material has been tested at A. & M. College and indicates that the deposit contains about 75 per cent coarse gravel, 19 per cent clay, and the remaining part sand. It has been used on roads in Grimes, Liberty and Montgomery counties.

One gravel deposit belonging to E. A. Edwards of Shiro, Texas, produced about 30,000 yds. in one year. This pit is located on a spur of the T. & B. V. Railroad, 1½ miles southwest of Shiro and about 1,200 yds. from the main line of the railroad. The pit covers about 25 acres and is from 10 to 25 ft. in depth. This material has been used on roads in Montgomery, Liberty, and Grimes counties. Another deposit of flint gravel is located on the T. & B. V. Railroad, 72 miles north of Houston, at Shiro, Texas, and can produce from 6 to 15 cars a day with wheel-scrapers. The tests of this gravel follow:

MECHANICAL ANALYSIS

	No. 1
Material retain on 2-inch sieve	0
Material retained on 1-inch sieve	.8
Material retained on ½-inch sieve	10.2
Material retained on ⅛-inch sieve	45.7
Material retained on .033-inch sieve	67.6
Material retained on .0116-inch sieve	78.8
Material retained on .0058 inch sieve	82.3
Material retained on .0029-inch sieve	83.7
Material passing the .0029-inch sieve	16.2
Total	99.9
Cementing value on:	
Material over ⅛ inch in size	----------
Material under ⅛ inch in size	----------
Material as received	Excell.

No. 1. This gravel is taken from the property of E. A. Edwards, Shiro, Grimes County, located 1 mile south of Shiro, on the T. & B. V. Railroad spur. The test shows that the gravel has an excess of sand for the best results, but it should make good roads. The material is very good, and its cementing qualities are excellent.

A deposit of quartzite located 2½ miles north of Shiro, and ½ mile from the T. & B. V. Railroad is also owned by E. A. Edwards of Shiro. This material has never been commercially produced, but test-holes indicate that there is an enormous quantity present. A small sample on hand indicates that this is a very hard quartzitic sandstone, having rather low toughness. If of a uniform character this should be excellent material for a foundation course, with binder of other material, and should also make good railroad ballast. A deposit of sandstone belonging to W. B. Spencer of Richards, Grimes County, is located 1¼ miles east of the I. & G. N. Railroad and 2½ miles southeast of Bedias. It is also 1½ miles west of the T. & B. V. Railroad. A small sample on hand indicates that the deposit is rather variable, as a part of the sample is hard quartzitic sandstone in contact with soft sandstone. A deposit of soft and hard sandstone is located 27 miles north of Navasota on the I. & G. N. Railroad. This belongs to Mr. J. N. Robinson, Madisonville, Madison County. While the deposit is within 200 yds. of the I. & G. N. Railroad, it has never been commercially operated. It is reported that the deposit covers 19 acres.

The Texas Rock Company of Beaumont, Texas, owns a deposit of sandstone 1 mile south of Bedias, and ¾ mile west of the I. & G. N. Railroad. This deposit, however, is not being operated. At Piedmont, Texas, the Texas Sand and Gravel Company of Houston, Texas, operates a quarry for producing crushed and screened sandstone. During 1916, this plant produced approximately 40,000 tons of rock, which has been used as concrete aggregate and as rip-rap for jetty work. The deposit is on the H. & T. C. Railroad. An old quarry of sandstone and semi-quartzite is located a short distance west of the I. & G. N. Railroad (Madisonville Branch) between the 22 and 23 mile posts. The stone, however, is rather poor road material, but a satisfactory concrete aggregate where it is not needed to resist wear.

Guadalupe County

Two samples of gravel in this county have been tested as follows:

MECHANICAL ANALYSIS

	No. 1	No. 2
Material retained on 2-inch sieve	8.70	39.03
Material retained on 1-inch sieve	28.34	56.55
Material retained on ½-inch sieve	55.65	88.45
Material retained on ¼ inch sieve	76.54	99.91
Material retained on .033-inch sieve	83.92	-----
Material retained on .0116-inch sieve	92.53	-----
Material retained on .0058-inch sieve	94.66	------
Material retained on .0029-inch sieve	95.11	-----
Material passing the .0029-inch sieve	4.77	-----
Total	99.88	------
Cementing value on:		
Material over ⅛ inch in size	Poor	----
Material under ⅛ inch in size	Excell.	----
Material as received	Poor	----

No. 1. This gravel is taken from the north bank of Cibolo Creek, from test hole, about 17 miles north of San Antonio, on the Government Highway. The tests show this gravel as consisting of rounded fragments of a hard limestone with a small amount of calcareous sand. It should prove satisfactory as a road building material.

No. 2. This gravel is taken from the bed of Cibolo Creek, about 17 miles north of San Antonio and about 50 yards up the creek from the crossing of the Government Highway. The tests show that this material consists of large rounded fragments of limestone with no sand or clay. It should make satisfactory concrete aggregate, or, if mixed with sand and clay in right proportions, should make good road material.

Hamilton County

On the Leon River at Spur, Texas, a gravel deposit owned by Claude Huddleston of Hamilton, Texas, is located within close proximity of the St. Louis & S. W. Railroad.

Harris County

The Houston Transportation Company of Houston, Texas, markets a sharp San Jacinto River sand. The material comes

to Houston by boat and has been used extensively for concrete paving. During 1916, the output was over 10,000 tons.

Harrison County

This county is in the iron ore belt and this gives a ferruginous character to the natural material found in this county. One deposit of iron ore gravel has been tested as follows:

MECHANICAL ANALYSIS.

	No. 1
Material retained on 2-inch sieve	0
Material retained on 1-inch sieve	7.81
Material retained on ½-inch sieve	21.22
Material retained on ⅛-inch sieve	43.15
Material retained on .083-inch sieve	50.38
Material retained on .0116-inch sieve	52.44
Material retained on .0058-inch sieve	71.63
Material retained on .0029-inch sieve	84.98
Material passing the .0029-inch sieve	15.06
Total	100.04
Cementing value on:	
Material over ⅛ inch in size	Poor
Material under ⅛ inch in size	Poor
Material as received	Poor

No. 1. This iron gravel was taken from the Roseborough Springs Road, about 2½ miles southwest of Marshall. It was sent in by N. P. Turner, County Engineer, Marshall. The tests show that this material consists of some fragments of disintegrated sandstone and a large amount of fine sand with little clay. It is not recommended as a road building material, as it does not contain enough large stones to support traffic or enough clay binder.

A hematite deposit is located in east Texas iron ore fields at Ore City, 32 miles northeast of Longview, on a branch of the G. C. & S. F. Railroad. The deposit belongs to L. H. Featherstone of Beaumont, Texas. The shipping facilities for this material are the Port Bolivar and Iron Ore Railroad, a branch of the G. C. & S. F. Railroad. The material has been used on the Gregg County roads and has been reported satisfactory. A deposit of iron conglomerate has been tested as follows:

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.80	175	7.63	23.7	1.7	----------	---------	Good	4,670

No. 1. This sample of iron conglomerate was sent in by N. B. Turner, County Engineer, Marshall. It was taken from county property about 5 miles south of Marshall and about 2 miles west of the Carthage Road. The tests show that this material has a very low resistance to wear and to compression, but good cementing value. It is not recommended as a road building material, and should be used only for foundation course, if nothing else is available.

Hartley County

On the Fort Worth & Denver Railroad, 50 miles north of Amarillo, is a gravel deposit belonging to W. C. Reeves of Amarillo. During 1916, there were about 10,000 cu. yds. produced, and with present equipment, it is possible to reach 400 cu. yds. a day. The gravel is reported as being made up of 20 per cent coarse gravel, approximately 50 per cent sand, and the rest clay.

Hays County

There is, in Hays County, a network of roads totaling six hundred miles, which spread to all parts of the county. The greater part of these can be traveled with safety and comfort. Most improved highways, however, are close to the towns, the improvement becoming less and less apparent as the distances increase from the centres. This must be expected as the outlying communities cannot afford the advantages of a highly improved road nor does the volume of the traffic demand it. By using the best of available materials, many of these roads can be improved at a normal cost, as considerable road material is to be found in this county. The great body of the county is accessible to some type of material within reasonable hauling distances. In the eastern part of the county, in the black land prairie district, there is a marked absence of good road material, although good roads are needed here more than in the hills. The Aust-

San Antonio Post Road, running northeast to southwest through the county, marks in a general way the eastern border of the rock material. To the east of this in the black prairie country, a number of scattered deposits of gravel are located, while to the west of the road the predominating material is rock. Along the streams, there are many deposits of good road-building gravels. The characteristic of the material in this county is that most of it is limestone. This applies to the gravels as well as the rock. There are, however, a few flint and chert gravels and one dike of basalt or trap rock at the northern border of the county. The gravels generally are composed of medium sized pebbles and a small percentage of sand with little very fine material. The pebbles themselves are usually fairly hard and somewhat flat and smooth, but have good binding properties when crushed to dust. This makes them satisfactory road material. The coarse graded gravels, without doubt, are the most satisfactory, and are in fact absolutely necessary for the heavier traffic roads.

The limestones are about of the average quality of such material found in this state and only the hardest and toughest of these would prove satisfactory in road construction, especially if the traffic is in any way heavy. The trap rock out-cropping in this county is deserving of special mention for the reason that it is the best road material for plain macadam roads so far known in the state. It is hard and tough with a high resistance to wear and resistance to compression, assuring it of long life under heavy traffic. It is weathered just sufficiently to produce a good bonding material on the road under traffic. The unfortunate thing about the material is that it is located far from a railroad, being fifteen miles from Austin, the closest shipping point. However, for local use it should prove highly satisfactory.

Many limestones could be used satisfactorily in the construction of concrete roads as also would be the case with many of the limestone gravels provided they were washed and screened. Limestone should have a compressive strength of over ten thousand pounds to be considered for this purpose. The only plant existing in this county producing these materials on a commercial scale, is the plant of the San Marcos Gravel Company, located on the banks of the Blanco River about one mile east of

San Marcos. At the present time this plant is not being operated, but in 1916, it produced about two hundred yards of washed and screened gravel and fifty yards of washed sand per day. The gravel is taken from the bank of the river opposite the plant by means of a slack-line excavator which is unloaded into a receiving hopper and in turn is discharged into a 1½ yard tram bucket which conveys it across the river up an incline to the plant. An automatic release causes this gravel to drop into a hopper about 40 feet above the ground, where it passes over a set of parallel bars spaced two inches apart so that the stones above two inches will fall into a No. 4 gyratory crusher. The material issuing from this crusher, together with the gravel and sand below two inches in size, then passes into a bucket conveyor up to the scrubbers. The scrubber is a conical shaped cylinder having heavy fins which keep the gravel stirred, while a battery of water jets washes the material. The washed gravel and sand then pass into the screens.

Three screens serve to assort the gravel to the desired sizes, which are: 2 inches to 1 ½ inch, 1½ in. to ¾ in., ¾ in. to ¼ in., and the sand under ¼ in. Jets of water play on the gravel as it passes through these screens which all revolve on the one shaft so that the gravel passes from one to the other. The stones above the size of the screen pass into a large receiving bin.

The sand and silt passing the ¼ inch screen drop into a sand trap, which is a novel arrangement used to clean the sand from any silt that remains. It consists of a steel box so hung that when a definite amount of sand is caught, the weight opens two valves and discharges the sand into a bin where the coarse sand settles first and fine sand and silt pass off with the water back to the river, through flumes. This plant is operated by steam and employs usually ten men for its operation. The San Marcos Gravel Company supplies gravel in any of the sizes mentioned above or a combination of any of these sizes, as desired; but the usual demand is for concrete gravel between ¼ inch and 2 inches in size.

Tests made in the laboratory showed the material to be of high quality as a concrete aggregate. Tests on the sand compared with standard Ottawa sand showed 44 per cent greater

strength, which is a very good recommendation for it as a concrete sand.

Railroad ballast from this county is used by the I. & G .N. and the M. K. & T. railroads. They both have sidings at the edge of the Blanco River where they take from six to ten carloads of gravel daily. This gravel is taken from the bottom of the river with drag-line buckets and includes considerable sand and mud. It is used as ballast for the tracks and is considered quite satisfactory by the railroads. The M. K. & T. Railroad, however, uses a burnt clay on top of the gravel and between the ties as they consider this burnt clay ballast protects the ties from rot to a considerable extent. None of this gravel is sold.

A considerable number of samples was collected by the laboratory and tested making a more or less complete road material survey of the county. Tests of these materials with the locations and recommendations follow:

TABLE I

Test of Gravels of Hays County, arranged according to their Value as Road Material.

	Lab. No.	Characteristic Material Composing the Gravel.	Per Cent. Retained on Sieves					Passing No. 200 sieve	Cementing value			Recommendations
			2-in.	1-in.	⅛-in.	No. 48	No. 200		Above ⅛-in. sieve	Below ⅛-in. sieve	As received	
1	2482	Limestone	16	37	73	84	87	13	Poor	Excell.	Fair	Very good
2	2640	Hard chert	10	49	81	81	83	17	Poor	Poor	Excell.	Heavy traffic roads
3	3017	Hard and soft limestone	10	27	80	94	95	5	Poor	Good	Poor	Satisfactory
4	1930	Limestone	2	11	67	89	93	7	Poor	Fair	Fair	Satisfactory
5	1931	Limestone	10	34	78	92	93	7	Poor	Fair	Fair	Satisfactory
6	3061	Fairly hard limestone	0	10	88	94	99	1	Poor	Fair	Poor	Satisfactory
7	3036	Chert and limestone	20	29	78	94	99	1	Poor	Fair	Fair	Satisfactory
8	2051	Limestone	5	22	89	93	96	4	Poor	Poor	Poor	Satisfactory
9	2053	Limestone and clay	0	8	65	85	88	12	Poor	Good	Good	Satisfactory
10	2012	Limestone	6	13	78	94	95	5	Poor	Good	Poor	Satisfactory
11	2065	Limestone and clay	0	27	77	87	88	12	Poor	Excell.	Good	Satisfactory
12	2054	Limestone and clay	0	24	78	83	84	16	Poor	Excell.	Fair	Satisfactory
13	2057	Limestone	0	39	84	91	93	7	Poor	Good	Poor	Satisfactory
14	2021	Limestone	0	11	85	90	94	6	Poor	Good	Poor	Satisfactory
15	1985	Limestone	9	28	80	90	95	5	Poor	Fair	Poor	Satisfactory
16	3040	Limestone	7	26	86	94	97	3	Poor	Fair	Poor	Satisfactory
17	3022	Limestone	6	36	91	98	100	0	Poor	Fair	Poor	Satisfactory
18	2020	Limestone and flint	21	54	87	90	91	9	Poor	Fair	Good	Satisfactory
19	2018	Limestone	0	9	77	91	93	7	Poor	Poor	Poor	Fairly satisfactory
20	2023	Limestone	0	17	84	93	95	5	Poor	Poor	Poor	Fairly satisfactory
21	2011	Limestone	4	7	54	85	87	13	Poor	Good	Good	Fairly satisfactory
22	2017	Limestone conglomerate									Poor	Hard to work
23	3041	Limestone	20	60	87	89	90	10	Fair	Good	Fair	Crush large stones
24	3042	Flint and limestone	20	50	77	82	84	16	Poor	Excell.	Fair	Remove large stones
25	3043	Flint and limestone	15	35	77	83	85	15	Fair	Excell.	Excell.	Remove large stones
26	3019	Hard and soft limestone	19	27	60	86	90	10	Poor	Fair	Poor	Satisfactory
27	3035	Limestone	0	10	83	94	99	1	Poor	Fair	Poor	Satisfactory
28	3034	Hard and soft limestone	0	17	84	97	99	1	Poor	Fair	Poor	Light traffic only
29	3039	Soft limestone and chert	13	39	88	89	90	10	Poor	Excell.	Good	Light traffic only
30	2032	Limestone	0	71	70	87	89	11	Poor	Fair	Poor	Light traffic only
31	3053	Flat limestone	19	47	79	87	90	10	Poor	Good	Fair	Light traffic only
32	3054	Hard and soft limestone	14	35	77	90	92	8	Poor	Fair	Fair	Light traffic only
33	3059	Soft limestone	10	28	73	96	100	0	Poor	Good	Good	
34	2027	Limestone	0	11	54	70	76	24	Poor	Fair	Good	
35	2019	Limestone conglomerate									Poor	
36	2026	Limestone conglomerate									Poor	
37	2022	Limestone	4	37	55	68	81	19	Poor	Good	Fair	
38	2024	Limestone	6	49	99	100						Not enough fine material
39	2049	Limestone	4	48	100							Concrete gravel
40	2067	Limestone	5	14	60	76	79	21	Poor	Excell.	Excell.	
41	2025	Limestone	5	15	99	100						Concrete gravel
42	2050	Limestone	0	0	99	100						Roofing gravel
43	2052	Very soft limestone									Poor	

LOCATION OF GRAVEL SAMPLES IN TABLE I, WITH USEFUL COMMENTS.

Map No.	Lab. No.	Location.	Remarks
1	2482	Property of P. T. Bost, about 4¼ miles southwest of San Marcos, about 200 yards west of I. & G. N. railroad, and about the same distance east of San Antonio-Austin road.	Gravel has proven satisfactory in practice.
2	2640	Barber & Evans farm, 5 miles east of Kyle, on Kyle-Goforth road. Also known as Turner farm land.	Gravel requires considerable traffic to compact it.
3	3017	Bed of Blanco river at Clark's Ford, about 3½ miles southwest of Kyle.	Gravel should be well mixed. Washed and screened the gravel should make excellent concrete material.
4	1930	Rilander pit, about 14 miles from Austin, on San Antonio-Austin road.	A road gravel that will compact rather quickly.
5	1931	Town of Buda.	A large open pit.
6	3001	Onion Creek at ford where the Kyle-Dripping Springs Road crosses the creek.	Considerable gravel. Washing and screening would make it satisfactory concrete aggregate.
7	3026	Sheevitt's pit on Hays-Caldwell county line road, 1 mile south of Uhland.	Large pit worked with plow and loading trap.
8	2051	About ¾ mile east of Austin-San Antonio road, on county poor farm.	A road of this gravel would need considerable traffic before it consolidated.
9	2053	About ¾ mile east of Austin-San Antonio road, at county poor farm.	A satisfactory gravel.
10	2012	Pit in M. M. Sylers' pasture, on bank of Onion creek, Buda-Kyle mountain road, about ¾ mile southwest of Buda, and about 1-3 mile west of I. & G. N. railroad.	Large quantity of this.
11	2065	Swancoat property, about 2¼ miles southwest of San Marcos, on the San Antonio-Austin road.	As with all gravels, the large stones should be removed.
12	2054	Frank Johnson's land, about 2 miles southwest of San Marcos, old pit on east side of road, on Austin-San Antonio road.	Old large pit on east. Flat stones will make this a hard gravel to consolidate.
13	2057	Hutchens' land, prospect pit, about 2½ miles southeast of Kyle, about 200 yards east of I. & G. N. railroad, on San Antonio-Austin road.	A hard gravel to consolidate, but will wear longer than if it were otherwise.
14	2021	Pit on land of Brown Bros., Austin, known also as the McBee place, about 3½ miles southeast of Kyle, on Lockhart road.	Considerable gravel here.
15	1985	Blanco river, Hays County.	This gravel should be well mixed. May prove hard to consolidate in road.
16	3040	Ford on San Marcos river at the Hays-Caldwell county line, 4 miles southeast of San Marcos.	Large pit with loading trap. Exposed 10 feet and considerable gravel already used.
17	3022	Pit on road on east side of Blanco river, 3½ miles south by southeast of Kyle.	Pit opened to 125 feet and 12 feet deep, generally uniform; can be removed with pick or plow.
18	2020	J. A. Heidenreich's large pit about 200 yards east of pit represented by Sample No. 2018.	Used on Lockhart-Kyle road.
19	2018	Abandoned pit about 200 yards west of pit now being worked, 2¾ miles southeast of Kyle and about 1½ miles east of San Antonio-Austin road, on Lockhart road.	Large pit. Binding properties of gravel somewhat poor.

20	2023	I. & G. N. railroad cut just north of I. & G. N. bridge across the Blanco about 4½ miles south of Kyle, near San Antonio-Austin post road.	Considerable traffic is needed to consolidate this gravel.
21	2011	Pit on land of Brown Bros., Austin, Travis County, known also as the McBee place, about 3½ miles southeast of Kyle, on Lockhart road.	Contains an excess of fine material, which permits washing, and is apt to be somewhat dusty.
22	2017	Pit on San Antonio-Austin road, between gin and Manchaca road, about 2½ miles north of Buda.	Not economical to use as it would have to be broken before being used.
23	3041	Head of Cottonwood Creek, 4 miles south of San Marcos.	Layer of this gravel 2½ feet deep with 2 feet overburden. Could not be worked economically.
24	3042	On creek bank, 8 miles south of San Marcos and about 400 yards from county line.	Deposit is from 3 to 5 feet deep and 300 feet long, as exposed, with from 1 to 4 feet overburden. Stands well in bank and could be removed with plow and scrapers.
25	3043	About 1½ miles southwest of sample No. 3042 and 400 yards west of county line.	Deposit exposed 7 feet in depth, and 300 feet in length. Stands well in bank and can be easily removed.
26	3019	Bank at side of dry creek bed 2 miles west by southwest from Kyle, on road to pumping station.	Good gravel bank but heavy overburden. Probably uneconomical to work.
27	3035	About 4½ miles southeast of Kyle, just off Kyle-Lockhart road.	Large pit, stands well in bank, but would probably have to be blasted.
28	3034	About 3½ miles southeast of Kyle, on Kyle-Lockhart road.	Pit-opened-gravel is somewhat cemented together and probably needs blasting. Road in which this gravel is used is dusty.
29	3039	Just at San Marcos city limits, about 1 mile due south from M. K. & T. railroad station.	Small exposure (about 2000 to 3000 cubic yards). Stands erect in pit about 8 feet.
30	2032	Eugene Woods' land, about 1¼ miles north of Kyle, on San Antonio-Austin road.	A conglomerate that is soft and hard to handle.
31	3053	Bank beside Cypress Creek, 200 yards south of Jacob's Well.	Gravel stands well in bank, exposure 2½ feet thick and 700 yards long.
32	3054	Exposure on road along Blanco river about 1 mile south of Wimberley.	Considerable large stones that must be removed.
33	3059	Mouth of creek emptying into Onion Creek, 3 miles west of Dripping Springs on road to Fisher's Store.	Exposure stands erect, 8 feet by 50 feet, but runs back a considerable distance. One foot overburden.
34	2027	Pit 3½ miles southwest of Kyle on Old Government road.	Contains too much fine material to build an enduring road.
35	2019	J. A. Heidenreich's old pit, includes hard formation above gravel.	Conglomerate that could not be worked economically.
36	2026	Two miles west of Kyle, Hays County on old Government road.	Same as preceding.
37	2022	About 100 yards east of San Antonio-Austin road, and 100 yards east of I. & G. N. railroad, 3½ miles south of Kyle.	Contains too much fine material to build an enduring road.
38	2024	F. M Warnken's land, pit on I. & G. N. railroad spur to Blanco river, 5 miles south of Kyle.	Sample is probably not representative of pit.
39	2049	San Marcos Gravel Co., about 1 mile east of San Marcos on Blanco river.	Concrete gravel washed and screened.
40	2067	F. Weigrane property, about 5¾ miles southwest of San Marcos, about ½ mile northwest of San Antonio Austin road.	Contains too much fine material to make an enduring road.
41	2025	Blanco river just below I. & G. N. railroad bridge and the San Antonio-Austin road, about 5 miles south of Kyle.	Not enough fine material for road construction.
42	2050	San Marcos Gravel Co., 1 mile east of San Marcos.	Roofing gravel, washed and screened.
43	2052	About ¾ mile south from wagon bridge over Blanco river, on Austin-San Antonio road, and about 75 yards west of I. & G. N. railroad.	Gravel is too soft to be satisfactory.

TABLE II.

Tests of Basalt Limestones of Hays County, arranged according to their value as Road Material.

Map No.	Lab'y No.	Wt. per cu. ft. solid lbs.	Lbs. water absorbed per cu. ft.	French coefficient of wear	Hardness coefficient	Toughness	Cementing value	Compressive strength lbs. per sq. inch	Kind of Traffic for Which Material Is Recommended	
									Waterbound Macadam	Bituminous Construction
						Basalt (Trap Rock)				
Aa	3139	187	1.04	14.5	18.1	16	133	24,300	Heavy or Medium	Heavy or medium
						Limestone				
A	3014	165	1.29	----	15.4	5	34	21,525	Medium traffic	Medium traffic
B	2055	162	2.15	10.7	14.2	7	42	11,000	Light traffic	Medium traffic
C	3058	162	2.13	7.8	16.1	6	76	16,625		Medium traffic
D	2014	156	3.34	9.9	13.9	6	12	13,375	Light traffic	Light traffic
E	3028	165	0.74	7.6	16.0	5	77	18,450	Light traffic	Light traffic
F	1929	156	4.50	11.6	10.6	5	9	10,025	Light traffic	Light traffic
G	3015	165	1.82	7.1	14.1	5	83	15,800		Light traffic
H	2013	165	1.10	8.9	13.3	4	15	10,650	Light traffic	Light traffic
I	3032	159	1.92	8.3	11.9	6	68	15,300		Light traffic
J	2033	162	1.92	7.0	14.4	5	8	------		Light traffic
K	3012	159	1.70	----	12.5	5	47	15,975		Light traffic
L	3044	165	0.50	6.7	12.3	5	26	14,188		Light traffic
M	3030	159	1.90	6.2	12.7	4	17	14,225		Light traffic
N	3033	162	1.00	7.8	14.3	4	37	13,280		
O	3031	162	----	9.4	14.5	3	9	11,060		Very light traffic
P	2056	159	3.44	8.3	9.3	5	38	10,750		Very light traffic
Q	2031	162	1.47	7.0	9.9	4	14	7,790		Very light traffic
R	2030	159	2.35	6.8	10.0	4	16	8,650		Very light traffic
S	2015	159	2.36	7.6	8.7	4	15	10,260		Very light traffic
T	3029	159	2.19	5.7	12.1	4	32	8,050		Very light traffic
U	3031	162	3.05	6.4	10.4	3	42	10,950		
V	3060	162	1.77	7.1	13.9	3	49	10,515		
W	3018	159	3.22	----	10.5	4	29	9,200		
X	3013	162	1.54	5.3	8.2	--	36	------		
Y	2029	150	5.99	5.3	0.0	3	99	8,050		
Z	2028	147	7.56	6.2	0.0	3	52	------		

LOCATIONS OF SAMPLES IN TABLE II, WITH USEFUL COMMENTS

Map No.	Lab. No.	Location.	Remarks.
Aa	3139	Just northwest of intersection of 90° Meridian with the Hays-Travis County line and north of the Austin-Dripping Springs road.	An excellent rock for water bound bituminous construction or concrete road.
A	3014	Nance's property on trail past windmill in pasture about 2½ miles from Blanco river ford.	Georgetown formation, somewhat weathered, and not uniform in deposition.
B	2055	U. Williams' land 2¼ miles south of San Marcos on San Antonio-Austin post road, 50 yards west of I. & G. N.	Will do for road construction and railroad ballast.
C	3058	Outcropping on San Marcos-Wimberly road, 10½ miles west of San Marcos.	A fairly good material, but gravel would be more economical in this locality.
D	2014	About 4 miles southwest of Buda on Buda-Kyle mountain road, and about 1 mile west of I. & G. N.	Good exposure of this rock.
E	3028	About 8½ miles from I. & G. N. station in San Marcos, San Marcos-Wimberley road, and 3½ miles from forks of Blanco city road.	Edwards limestone, weathered. A movable crusher plant along here would permit of a cheap macadamized road, as there is no gravel near here.
F	1929	Onion Creek just above I. & G. N. railroad bridge, and about ½ mile north of Buda.	Light exposure but gravel roads would be better than this rock.
G	3015	Outcropping along trail leading to 1000-foot hill 3½ miles west of Nance's ford and Blanco river.	Easy rock to quarry and appears uniform; but little use for rock in this locality.
H	2013	About 3 miles west of Buda on Buda-Kyle mountain road, about ½ mile west of I. & G. N. railroad.	Light exposures of this stone but gravel would be more economical in this locality.
I	3032	Outcropping on trail leading off post road and about four miles southwest of San Marcos.	Edwards limestone that should prove fairly satisfactory for a concrete or bituminous road, or as railroad ballast.
J	2033	Deshay Bunton place 200 yards up Plum Creek from San Antonio-Austin post road bridge.	Not very large exposures and could only be used in bituminous construction.
K	3012	Outcropping in creek bottom in Nance's pasture, about 1 mile from windmill.	Edwards formation, but rock is unfavorably located.
L	3044	Outcropping on Wills Dairy property, near San Marcos on Blanco City road, about 2 miles from San Marcos.	A low resistance to wear does not warrant this as a first-class stone, but should make satisfactory with bituminous surface.
M	3030	Mrs. Hillyer's property about 2 miles from Post road, and 2½ miles north of San Marcos.	Small amount of stripping and good outcrop, but stone is too soft to warrant working.
N	3033	Same locality as Sample No. 3032.	Known as "Austin marble"; takes a high polish, giving a very pleasing stone for interior decoration.
O	3031	Voss place, on Austin-San Antonio post road, 400 yards west of I. & G. N. railroad, and 3 miles southwest of San Marcos.	An excellent place for a quarry site, but stone does not warrant the investment.

LOCATIONS OF SAMPLES IN TABLE II, WITH USEFUL COMMENTS—Continued

Map No.	Lab. No.	Location.	Remarks.
P	2056	John Benneck's land, 1½ mile southwest of San Marcos, and 200 yards, north of post road, and about ¾ mile northwest from I. & G. N. railroad.	Considerable rock here, but it is too poor in quality to develop.
Q	2031	Eugene Woods' land 1¼ miles north of Kyle, 1 mile east of I. & G. N. railroad, on Austin-San Antonio post road.	Its quality does not warrant development of deposit.
R	2030	John Arbor's land, 1 mile north of Kyle, near I. & G. N. railroad, on Austin-San Antonio post road.	Resistance to wear and toughness are much too low for road construction.
S	2015	About 5½ miles southwest of Buda and 1 mile west of I. & G. N. railroad, on Buda Kyle mountain road.	Not worth developing.
T	3029	Outcropping on road leading off post road northwest, about 4 miles from San Marcos, and 1½ miles from I. & G. N. railroad.	Weathered out-cropping of Buda limestone which does not warrant development.
U	3031	Ledge at ice house lake at head of San Marcos river, San Marcos.	Georgetown limestone which is too soft to be of use in road construction.
V	3060	About 2 miles east of Hays City on Kyle-Hays City road.	No use as road material, but is a good building stone.
W	3018	Bank of Blanco river about 2½ miles northwest of I. & G. N. bridge.	Ledge 20 feet high above low water, but too soft.
X	3013	Gates Nance property, just beyond house on road to windmill.	Outcropping seems uniform.
Y	2029	From 3 miles southwest of Kyle on old Government road.	Stone much too soft for modern traffic.
Z	2028	About 3½ miles southwest of Kyle on old Government road, near gravel pit.	Soft and brittle stone.

Hidalgo County

Two miles west of Sam Fordyce on the St. Louis, Brownsville, and Mexico Railroad, is located a gravel pit, which is owned by the railroad and the present operator. During 1914, this pit produced 200,000 yds. of gravel, and now the daily production is 950 yds. The gravel has been used on roads in Hidalgo County, and as railroad ballast for the St. L. B. & M. Railroad. Another deposit at Penitas is operated by J. A. Card of Mission, Texas. The material produced is screened and pit-run gravel. During 1916, about 12,000 tons were produced and with the present equipment, it is possible to produce 140 tons of screened gravel daily, and about 300 tons of unscreened gravel and 240 tons of sand. The pit is located on a switch of the St. L. B. & M. Railroad and the material has been used on the streets of Brownsville, McAllen, Mission, and Kingsville. On the Rio Grande Bluffs, 3 miles below a Mexican town, Las Cuevas, is located a hard, compactly cemented gravel, 10 ft. thick. The nearest railroad, however, is the St. L. B. & M. Railroad, some distance away.

A caliche is produced by the Sam Fordyce Gravel Co. of Edinburg, Texas. It is on a spur, 1 mile from the St. L. B. & M. Railroad, and has been used in road work in the lower Rio Grande Valley. During 1916, the output was approximately 20,000 tons, and with the present equipment, the daily output is 400 tons. A small sample on hand shows that this caliche is composed of small pebbles of flint and quartz, below 3/8 in. in size, suspended in calcareous flour. The greater proportion of the material is calcium carbonate.

One limestone produced by the Monte Christo Quarry Co. owned by Heath May, Mission, Texas, has been tested with the following results:

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.60	162	2.25	5	8	12.3	5	Excel.	13,000

No. 1. This limestone sample was sent in by the Monte Christo

Quarry Company (Heath May, Mission) and was taken from their property 1½ miles south of Monte Christo, Texas. The tests show that this is a rather soft rock, low in toughness, with medium resistance to wear and excellent cementing value. It also has fair resistance to compression. Should be satisfactory for plain macadam roads subjected to light traffic, or under medium traffic in bituminous construction.

Hill County

A deposit of gravel in this county is located 2 mi. north of Blum, 15 miles south of Cleburne, near the Santa Fe Railroad, belonging to S. W. Smith, of Blum, Texas. No spur to the Santa Fe Railroad exists at the present time. A test pit indicates that there is a considerable quantity of this gravel.

Hopkins County

Some weathered sandstone is found as loose rocks on a 400 acre tract of land belonging to W. A. Smith of Sulphur Springs, Texas. The material is located 4 mi. east of Sulphur Springs, on the Maria J. de Los Santos Coi Survey between the Cotton Belt and the M. K. & T. railroads, and 1 mi. from each. Some small samples examined appear to be rather variable, some pieces being quite hard, while others are considerably weathered and brittle.

International Boundary

In the Muleros Mountains, ¾ miles northeast of Juarez, is a porphyritic syenite. The International Boundary passes through the center of the peak, the principal mass being found in the central and highest peak, while another important mass is found in the mountain to which the Sierra de la Mina and Sierra de la Cruz belong. There is also a considerable dike which forms the highest point of the Sierra Prieta on its southern slope.

Jack County

In this county the well-known Jacksboro limestone is produced. This material has been used in road construction in many of the

counties and towns in north Texas, especially in Tarrant, Dallas, and McLennan. The owners of this quarry are Risley Bros. at Jacksboro, but the plant is now closed down. Equipment is on hand, however, to produce 600 tons of 2½ in. stone per day. The quarry is located on the C. R. I. & G. and G. T. & W. railroads. The only test of this material for road construction is an incomplete test made by the United States Office of Public Roads, as follows:

Sp. Gr.	Wt. per cu. ft. Solid	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
2.65	165	1.94	----	8.0	----	----	Good	------

Tests made on the material as a concrete aggregate by the Road Materials Laboratory of the University of Texas showed this stone to be a satisfactory concrete aggregate developing a compressive strength of over 2,000 lbs. in the 28 day tests.

Jasper County

In the northeastern part of the county, near the G. C. & S. F. Railroad, are located numerous deposits of gravel on the summits of the hills and ridges. These deposits have very large amounts of ferruginous cemented coarse grit and gravel. Mossy Hill is the name of a ridge several hundred yards long, northeast of the old Truitt Place, near the head of Beef Creek, covered with ferruginous cemented gravel at least 20 ft. thick. At the north end of Robert Stone Quarry on the north side of Beef Creek, and about 1 mi. from the Burr's Ferry, Browndell and Chester Railroad, is located a sandstone deposit belonging to Alexander Gilmer Lumber Co. of Remlig, Texas. This material is rather poor road material, but might be satisfactory as railroad ballast. Practically all the sandstone in the northwestern part of Jasper County, west of the G. C. & S. F. Railroad, is near the Burr's Ferry, Browndell, and Chester Railroad.

Jeff Davis County

There is very little need for road material in this county, as it is sparsely populated, and certainly there will be few roads constructed in the near future, unless something unforeseen happens. There are, however, many good deposits of road material to be found. A syenite porphyry forms the Sawtooth Range, the highest summit of the Davis Mountains. There are, in the Davis and Barilla mountains and the country along the Southern Pacific Railroad between Altuda and Marfa, many deposits of rhyolite, andesite, trachyte, and phonolite lavas, with breccias, conglomerates, and tuffs. Many of these, however, are not satisfactory as road material. Around Chispa, on the Southern Pacific Railroad, are many deposits of various volcanic rocks, and vesicular lavas, especially in the mountains east of Chispa, that are worthy of note. Six miles south of Chispa, some rhyolite basalt and conglomerate form the peak in the Tierra Vieja Mountains. Between the Wylie and Davis Mountains is found a phonolite deposit.

Jefferson County

There is very little material for road construction to be found in this county. The only material noted is the oyster-shell dredged at Sabine by W. D. Haden, Dredge Contractor, Sabine, Texas. It is possible to produce 3,000 cu. yds. a day with present equipment, which can be loaded on the Southern Pacific Railroad, or at any ports. It has been used on the city streets of Orange and on the Orange County roads.

Jim Hogg County

In this county there is a deposit of quartzitic gravel 2 mi. east of Hebbronville, on the Texas-Mexican Railroad, on the Dry Creek bank. This deposit belongs to W. W. Jones, but J. T. Nall has the material leased and operates a gravel-screening plant. There is a spur from the Texas-Mexican Railroad running to the plant 1,000 ft. from the main line. Mr. A. T. Nall has also leased a deposit of caliche, containing about 60 per cent gravel,

from ¼ in. to 2½ in., on the property of Viggo Kohler, 1½ miles from the Texas & Mexico Railroad and 2 miles from Hebbronville, in the Dry Creek bed. So far this material has not been produced. The caliche may be found with varying quantities of gravel. One sample of the gravel was entirely free from the soft calcareous dust. From the appearance of the material it is evident that it should make satisfactory roads, but they are apt to be dusty in dry weather, unless capped with some dust preventative.

Jim Wells County

Only one material is listed for this county, and it is a very soft limestone, found on the Richard King Ranch, near Alfred, Texas. It is useless as road material, although it is found close to the S. A. & A. P. tracks.

Jones County

At Lueders in this county, on the M. K. & T. Railroad, there is a deposit of limestone belonging to A. C. Fox. This is located ½ mile south and ¾ mile southeast of Lueders, and tested as follows:

Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
2.55	159	4.19	5.0	8.0	13.3	3	169	14,325

The tests show that this is a soft rock, with medium resistance to wear, very low toughness, excellent cementing value, and fair resistance to compression. It is only recommended for light traffic, with bituminous binder.

This crushed stone has also been tested as a concrete aggregate, and was found to be quite satisfactory for this purpose, developing over 3,000 lbs. per sq. inch compressive strength in a 28 day test.

Karnes County

As a whole, the good road material is rather scarce in this county. There is a coarse white limestone, which is found on the hills along the roads.

There is also a considerable amount of the quartzitic sandstone found in this county, but practically all of it is rather soft and has little resistance to wear. In the Tordilla Mountains, in the western corner of the county, is found a 20 ft. deposit of hard quartzitic sandstone. Some little distance from the S. A. & A. P. railroad, are numerous deposits of this sandstone, especially near Falls City. A 5 ft. deposit is located 2 miles southeast of Falls City, and another, 1 mile southwest of the town in the bluffs on the San Antonio River, ¼ mile west of mile-post 192 on the S. A. & A. P. Railroad. This deposit, however, would be of little use as it has approximately 17 ft. of overburden. Four miles west of town is a 30 ft. deposit of the sandstone, also on a bluff on the San Antonio River.

One mile northwest of Hobson is a 10 ft. deposit of soft sandstone beneath a 4 ft. overburden. This material is located on the S. A. & A. P. Railroad, but is much too soft to be recommended for road construction. Another deposit is found in the bed of the San Antonio River, just below the bridge, ⅓ mile southeast of Hobson.

Kaufman County

A deposit of gravel from the McGregor pit near Dallas, tested as follows:

MECHANICAL ANALYSIS

	No. 1
Material retained on 2-inch sieve	0
Material retained on 1-inch sieve	1.7
Material retained on ½-inch sieve	15.2
Material retained on ⅛-inch sieve	60.4
Material retained on .033-inch sieve	79.0
Material retained on .0116 inch sieve	91.9
Material retained on .0058-inch sieve	94.8
Material retained on .0029-inch sieve	95.7
Material passing the .0029-inch sieve	4.2
Total	99.9
Cementing value on:	
Material over ⅛ inch in size	Poor
Material under ⅛ inch in size	Fair
Material as received	Poor

The tests show that this material consists essentially of hard pebbles of limestone with some flint and quartz sand and a very little iron oxide clay, or silt which covers the stones. This is not a first class road-building gravel, and therefore it is only recommended for use when nothing better is available.

Kerr County

A limestone gravel belonging to Moore Brothers at Center Point, Texas, is located ½ mile south of the S. A. & A. P. Railroad and east of Center Point. It has been used on roads in Kerr County. It is a limestone gravel, the pebbles of which are small in size, being below ¾ in. and having a small amount of clay. There is also a deposit of calcareous powder on the same property, and it is reported that this latter material is satisfactory for a binder.

Kinney County

In this county there is considerable good stone suitable as road-building material, namely the basalts which are found in considerable quantities. The limestones are rather poor in quality, but some of the gravel located here might be called quite satisfactory. A deposit of basalt 30 ft. thick is located at Palmer Hill; another deposit of approximately the same thickness is located at Pinto Mountain, north of Ft. Clark; still another thinner outcropping is found at Little Pinto Mountain. North-northeast of Ft. Clark is a deposit of 70 ft. thickness, on a hill 2 miles north of Las Moras Mountains, while the mountains themselves embrace a deposit 90 ft. thick. At Elm Mountain the basalt is but 35 ft. thick. The nearest shipping point for all these deposits is perhaps at Spofford, on the Southern Pacific Railroad. It is believed that almost any of the deposits named above would make excellent road material. At Turkey Mountain, northwest of Cline, is another deposit 200 ft. thick. The nearest shipping point for this material would be Cline, on the G. H. & S. A. Railroad.

There is a number of gravel deposits in this county, particularly in the drainage basins of the tributaries of the West Nueces River, especially Griffin, Sycamore, and Dry Sycamore

creeks, in the central northern part of the county, near the county line. Along the course of the West Nueces River, are also deposits of flint and limestone gravel. Some of these deposits are as thick as 50 ft. and it is believed that they would make very good road material. The nearest shipping points, however, would be at Spofford and Cline.

In the southeastern part of the bluff on Sycamore Creek at the junction of the creek with the Rio Grande River, is a deposit of chalky gravel, from 20 to 30 ft. thick, but it is doubtful if it would prove satisfactory.

Kleberg County

The gravel from this county has been tested as follows:

MECHANICAL ANALYSIS

	No. 1
Material retained on 2-inch sieve	0
Material retained on 1inch sieve	17.1
Material retained on ½-inch sieve	45.2
Material retained on ⅛ inch sieve	82.9
Material retained on .033-inch sieve	88.5
Material retained on .0116-inch sieve	91.3
Material retained on .0058-inch sieve	95.1
Material retained on .0029-inch sieve	97.6
Material passing the .0029-inch sieve	----
Total	100.0
Cementing value on:	
Material over ⅛ inch in size	Excellent
Material under ⅛ inch in size	Excellent
Material as received	Excellent

No. 1. This gravel was sent from Kingsville, the owner being T. R. Cochran, Sam Fordyce, Hidalgo County. The sample was sent in by H. C. Porter, City Engineer, Kingsville, Texas. The tests show that this sample is composed of rounded fragments of quartzite, flint and limestone, cemented together with calcareous material, containing no clay. This material should prove fairly satisfactory, if crushed and used under considerable traffic. Lab. No. 2785.

Lavaca County

At Moulton, a stone quarry has been operated for a number of years by the Moulton Sandstone Company. The shipping facilities are at Moulton, by means of the S. A. & A. P. Railroad. Some tests made on this material show the following results:

Pounds of water absorbed per cu. ft.	10.48	lbs.
Weight per cu. ft.	137.8	lbs.
Crushing strength per sq. in.	4,311	lbs.

Lee County

A gravel deposit, which has been worked to a considerable extent, is located 3½ miles from the H. & T. C. Railroad, 2½ miles from the Dallas & San Antonio Short Line, and 6 miles from Giddings on the public road. It belongs to August Baack, Route 2, Giddings, Texas. During 1916, about 2,000 yds. were produced, but at the present time, no equipment is on hand. In 1916, a steam-shovel was used to load gravel on the wagons. The gravel was used on 3½ miles of the Giddings-Caldwell county road. It is reported that the deposit contains about 30 acres of gravel, 3½ ft. deep. A small sample on hand, shows that the gravel is composed of flint and quartz gravel, which has the appearance of being crushed, and has little sand or clay. Another deposit of gravel belonging to Joeckel and Williams at Giddings, has been tested. The deposit is directly on the H. & T. C. Railroad nine miles from Giddings. The report on the tests is as follows:

MECHANICAL ANALYSIS

	No. 1
Material retained on 2-inch sieve	2.3
Material retained on 1-inch sieve	31.3
Material retained on ½-inch sieve	49.0
Material retained on ⅛-inch sieve	69.9
Material retained on .033-inch sieve	76.8
Material retained on .0116-inch sieve	83.4
Material retained on .0058-inch sieve	88.8
Material retained on .0029-inch sieve	92.4
Material passing the .0029-inch sieve	7.7
Total	100.1
Cementing value on:	
Material over ⅛ inch in size	Poor
Material under ⅛ inch in size	Excellent
Material as received	Fair

The tests show that this gravel is composed of more or less rounded fragments of quartz and flint, well graded, and of good binding clay. It should make a very good material for gravel roads, and with the clay washed out, it should make an excellent concrete aggregate. After the clay was washed out, the gravel was made into concrete 1:6 mix by weight. 6″ cylinder cured 7 days in wet sand, then in air, tested at 28 days, gave crushing strength per square inch of 3,860 lbs.

Liberty County

About 3 miles distant from the Houston, East and West Texas, and the G. C. & S. F. railroads, is a deposit or gravel, mixed with coarse whitish sand, known as Roark's Gravel Pit. This deposit is 3 miles north of Cleveland. The gravel is about 8 ft. in depth and covers approximately 280 acres, with the east fork of the San Jacinto River forming one of the boundary lines of the tract. In this county the Romayor Gravel Company of Beaumont, Texas, operates a washing and screening plant on the Trinity River, close to the G. C. & S. F. Railroad. In 1916, the output amounted to about 40,000 tons of gravel, while equipment is on hand to produce 400 tons of screened gravel or 800 tons of pit-run gravel per day. It has been used for concrete base of streets and as railroad ballast on the G. C. & S. F. Railroad. Tests have been made on this material, with the following results:

MECHANICAL ANALYSIS

	No. 1
Material retained on 2 inch sieve	0
Material retained on 1-inch sieve	5.6
Material retained on ½-inch sieve	32.8
Material retainel on ⅛-inch sieve	64.5
Material retainel on .033 inch sieve	76.3
Material retained on .0116-inch sieve	96.1
Material retained on .0058-inch sieve	99.0
Material retained on .0029-inch sieve	99.5
Material passing the .0029-inch sieve	0
Total	99.7

By adding about 15% clay, the cementation value would be materially increased and brought within the allowable limit. This sample of gravel was sent in by Geo. W. White, County Engineer, Beaumont, Texas. The material is well graded from 1″ size down.

ROMAYOR GRAVEL COMPANY'S SAND

On Santa Fe Railroad Near the Trinity River. Laboratory No. 3001.

Weight per cubic foot, loose and undried	101 pounds
Weight per cub'c foot, loose and dried	111½ pounds
Weight per cubic foot, packed and dried	115¾ pounds
Voids in loose sand	29.5 per cent.
Voids in packed sand	21.2 per cent.
Specific gravity	2.65 per cent.
Moisture	1.9 per cent.

1 TO 2 BY WEIGHT TENSION TESTS

Specimen	Pounds per Square Inch		
	Three days	Seven days	28 days
No. 1	360	470	---
No. 2	375	450	---
No. 3	410	405	---
No. 4	400	420	---
Average	386	436	---

STANDARD OTTOWA (1 TO 2) BY WEIGHT

Specimen	Pounds per Square Inch		
	Three days	Seven days	28 days
Average of 4	339	421	---

1 TO 2 BY VOLUME TENSION TESTS

Specimen	Pounds per Square Inch		
	Three days	Seven days	28 days
No. 1	380	475	540
No. 2	405	460	525
No. 3	370	470	505
No. 4	350	450	490
Average	376	464	512

STANDARD OTTOWA SANDS, 1 TO 2 BY VOLUME

Specimen	Pounds per Square Inch		
	Three days	Seven days	28 days
Average of 4	325	421	476

Limestone County

In this county, two plants have produced crushed limestone, the one near Mexia, owned by the Springfield Rock Company of Mexia, the other at Tehuacana, operated by the Mexia Quarry Company of Galveston, Texas. Mr. W. S. Thompson of Tehuacana is the operator. This latter plant produced in 1916 over 20,000 tons of crushed stone, while the present output is about 400 tons per day. The plant is located on the T. & B. V. Railroad, and the stone has been used on roads in Limestone and Hardin counties, and also in concrete work. The Springfield Rock Co's. plant has been dismantled. Tests on these two materials show the following results:

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.60	162	----	6	6.7	12.8	4	114	14,425
2	2.50	156	----	8.2	4.9	4.2	4	Good	------

No. 1. This limestone was found at Springfield, Limestone County. It was taken from the property of the Springfield Rock Company, Mexia. The tests show that this is a soft rock, low in toughness and resistance to wear, excellent cementing value and fair resistance to compression. It is recommended only for light traffic.

No. 2. This fossiliferous limestone was found at Tehuacana, Texas. It has been tested by the United States Office of Public Roads, on May 28, 1915. This limestone is suitable for use in the foundation course in plain or bituminous macadam construction or as a coarse aggregate for concrete drainage structures. Might be used as a wearing course in plain macadam construction, where traffic is light, or bituminous macadam construction subject to medium traffic.

Live Oak County

Little stone satisfactory for road material is found in this county. The limestones are usually rather soft. A deposit of white limestones is located 3 to 4 miles east of Oakville, on the Oakville-Beeville Road. At the crossing of Lagarto Creek, by the Lagarto-Casa Blanca Road, is located a deposit of limestone 30 ft. thick. Also on the same creek, ½ mile northwest of La-

garto, at the crossing of the Frio Road by the Oakville-Tilden Road, is a deposit of gravel 3 ft. in depth. The gravel consists of pebbles from the size of a pea to 6 in. in diameter, composed of flint, silicified wood, chalcedony, agate, sandstone, and quartz. The nearest shipping point for this gravel is at Kittie, on the S. A., U. & G. Railroad. Close to Lagarto is a deposit of red clay gravel, the pebbles being composed of flint, limestone, and jasper.

Llano County

This county is noted for its hard and durable granites, but these materials are chiefly building stone and have not been used for road construction in this state. Some paving blocks have been made from this granite, which are said to have proven quite successful under heavy traffic. Disintegrated granites, however, have been used successfully for road construction, particularly when the traffic is not heavy. A test on gabbro from this county, from the old John Billingsley Place, on the property of Albert Rickerson, located 10 miles south and west of Llano, has been made with the following results:

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.75	172	0.21	1.7	23	18.5	18	26	26,300

The test shows that this is a hard rock, with very high resistance to wear, medium toughness, good cementing value and very high resistance to compression. This rock is excellent material for heavy traffic roads, as a concrete aggregate or railroad ballast.

A disintegrated granite on the property of D. W. Long of Kingsland, Texas, is located at French John Spur, 5 miles west of Kingsland, on the H. & T. C. Railroad. The equipment of the deposit is a loading trap on the H. & T. C. Railroad. A small sample on hand shows this to be disintegrated red granite, the particles being rather small in size, but with little clay. It is believed that the material would prove more satisfactory for making concrete, than as road material.

Madison County

A deposit of flint and quartz gravel is located 1¼ miles south of Madisonville, and ½ mile west of the I. & G. N. Railroad. There is at the present time no railroad spur to the property. The deposit is on the property of W. L. and Sam Lewis of Abilene, Texas. A small sample on hand is composed of rounded pebbles of flint and quartz with a small amount of sand and clay. One of the samples appears to have been washed and the sand removed. Another deposit of gravel located 1 mile south of Madisonville on the I. & G. N. Railroad has been used, according to reports, on the streets of Madisonville. The deposit is on the property of Sam Lewis.

Maverick County

There is little road material in this county, other than gravel. There is a number of deposits of gravel throughout the county. On the hills along the Eagle Pass-Carrizo Springs Road, for the first 20 miles out of Eagle Pass, are several gravel deposits. Some deposits of gravel and silt are found along the main Uvalde-Eagle Pass Road, between Chacon Creek and Salado Creek, and also from 1½ miles south of Salado Creek and 6½ miles toward Eagle Pass beyond the Uvalde-Eagle Pass Road crossing of Salado Creek and for the last 17 miles before it reaches Eagle Pass on the same road. These materials, however, are a considerable distance from the shipping point. A flint gravel mixed with silt is also found along the road from Cline to Eagle Pass, extending from the first crossing of Mule Creek, south to the Beasley Road to Chacon Creek.

Another deposit is found on the east side of Elm Creek, about 1 mile above the bridge on the Del Rio-Eagle Pass Road. Some further deposits of gravel and sand are located 12½ miles from Eagle Pass on the Upson-Eagle Pass Road on the plains above the breaks of the Rio Grande River. The nearest shipping point for this material is at Eagle Pass, on the G. H. & S. A. Railroad.

There is also a deposit of caliche, composed of some limestone pebbles surrounded by large amounts of soft, pulverized, chalky

limestone dust. This deposit is located 7 miles north of Eagle Pass, and also 1 mile from the Southern Pacific Railroad on the property of R. C. and Rocco De Bona, of Eagle Pass, Texas. There have been approximately 8,000 cu. yds. taken out with picks and shovels, and loaded in wagons. A small sample examined, however, was found to be unsuited for modern traffic roads, without some treatment to hold the dust in dry weather, and to prevent rutting in wet weather. It might be satisfactory as a foundation material under light traffic.

Matagorda County

The only material on record from this county is an oyster shell deposit in the bottom of Matagorda Bay. This material is dredged by W. D. Haden, American National Insurance Building, Galveston, Texas. The Haden plant is capable of delivering from 15,000 to 20,000 cu. yds. a month. The shipping point for this material is the G. C. & S. F. Railroad. There is located on this railroad a storage tank capable of holding 25 carloads.

McLennan County

Limestone and gravel are the road materials to be found in this county. The limestone, however, is on an average rather soft, and has little resistance to wear. A sample from a deposit 9 miles north of Waco was tested, resulting as follows:

No	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs per sq. in.
1	2.25	140	1.46	8.7	4.6	0	2	176	3,175

The test shows that this is a soft rock, with low toughness and resistance to wear, excellent cementing value and low resistance to compression. It is not recommended as a road-building material nor for railroad ballast.

A deposit of gravel belonging to the city of West, located 2½ miles southeast of the city, has been used on the McLennan

County roads. During 1916, approximately 6,000 tons were produced, which was loaded on wagons by hand. The M. K. & T. Railroad is 2 ½ miles from the pit.

McMullen County

While other materials are found in this county, the records are devoted entirely to sandstones. No tests have been made on any of them, however, and the locations are given without any knowledge of their value for road construction. In the bed of the Nueces River, in section 6, and ¾ mile north of Miles Ranch, is a deposit of this sandstone. A deposit 20 ft. deep is located 3¾ miles south of Crowther, near the northwest corner of the William D. Benham Survey. This sandstone extends in a northerly direction, to a point 3¼ miles south of Crowther. It is some distance from the S. A. U. & G. Railroad. Another deposit of 5 ft. of hard sandstone is located approximately 8 miles south of Crowther. A deposit from 5 to 10 ft. in depth is found also at 2 miles south, 10° east of Tilden, in the direction of the deposit mentioned above, on the Tilden-San Diego Road. Five miles south and 10° east of Tilden, also on the Tilden-San Diego Road, is a 23 ft. deposit of sandstone. On a hill 1½ miles south, 30° west of Crowther, is a 11 ft. deposit of sandstone, which like those mentioned above, is a considerable distance from the railroad so that should the sandstone prove satisfactory as road material, it would be hard to produce commercially.

Milam County

Two deposits of gravel from this county may be noted. One deposit is located 6 miles north of Thorndale, Milam County, and 6 miles from the railroad. It has been used on the Milam County roads, by the Milam County Road District, Number 6. J. H. Miller of Temple, Texas, owns a deposit of gravel 1¼ miles from the Port Sullivan bridge, and 1¼ miles from the I. & G. N. Railroad. Mr. Miller states that he has several acres of a red clay gravel about 4 ft. in depth. Under this road gravel he has a sandy gravel which when screened would be suitable for concrete work. This bottom stratum of gravel is

composed of 25 per cent gravel and 75 per cent sand. A sample of the latter gravel on hand is composed of flint, quartz, and limestone pebbles, free from clay. If screened to proper size, it should made a satisfactory concrete aggregate.

A ferruginous sandstone belonging to T. D. Gresham of Flippen, Gresham, and Freeman, Linz Bldg., Dallas, Texas, has been tested with the following results:

Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
2.75	172	0.44	23.6	1.7	8.5	5	9 Poor	10,200

The test shows that this is a soft stone, having low resistance to wear, low toughness, poor cementing value, and fair resistance to compression. This material is not recommended for road construction nor as a railroad ballast, as it lacks the necessary properties.

Montgomery County

In this county there are numerous deposits of road gravel, one of which has proven quite successful in road construction. There are also some deposits of sandstone, but none is worked to any extent. A deposit of flint gravel and sand graded up to 1½ in. is located on the property of E. V. Ley and associates of the Union Bank Bldg., Houston, Texas. The deposit is located 3 miles southwest of Dobbin, 1¼ miles west of the Trinity and Brazos Valley Railroad, on the Noah Griffeth and Bradberry Survey. There is no equipment on hand at the present time, as the material has never been used. Four miles southeast of Montgomery, about 4 miles east of Jackson, and 1½ miles south of the G. C. & S. F. Railroad, on the main road, is a deposit of gravel belonging to B. R. Yell of Conroe, Texas. The material has been used on the roads in Montgomery County. A small sample of this gravel indicates that the pebbles are small in size with considerable sand and clay. It is a flint and quartz gravel. This material should make a fairly satisfactory road, but it would wear better if the pebbles were larger in size. At Honea, 8 miles west of Conroe, on the G. C. & S. F. Railroad,

is another deposit of gravel and sand on the property of R. C. Collins of Conroe, Texas. There is no equipment on hand for loading, but the G. C. & S. F. Railroad tracks pass within ¼ mile of the deposit. A small sample of gravel shows that it contains considerable sand and clay, with about 47 per cent of flint and quartz pebbles under ¾in. in diameter. Like the preceding material, it is good topping gravel, but would wear longer with larger pebbles. A deposit of gravel located 7 miles west of Conroe 3,600 feet north of the Beaumont-Somerville Division of the G. C. & S. F. Railroad, is owned by W. P. McComb, road and gravel contractor of Conroe, Texas. The material is not produced on a commercial scale at the present time. A small sample on hand indicates that the material is composed of rounded pebbles of flint and quartz, with considerable sand and some clay. R. R. McPherson owns a deposit of coarse sand clay, 2 miles south of Montgomery, and 400 yds. from the G. C. & S. F. Railroad. It is reported that the deposit covers about 10 acres, and is 3½ ft. in depth. The pit has a comparatively clean, coarse sand at the top and the sand clay beneath, which, if mixed in equal parts, would produce an excellent sand clay topping. A small sample on hand indicates that the greater proportion of the material would pass through a ¼ in. screen. There is no equipment at the present time for loading the material. There are other deposits of gravel and sand in this county at many points between Shepherd and Willis on the I. & G. N. Railroad.

Navarro County

Only one gravel deposit is noted in this county. This deposit is located 8 miles north of Kerens, and 15 miles east of Corsicana, on the property of H. S. Keathley of Frost, Texas. The Cotton Belt Railroad, 8 miles away, is the nearest shipping point. This material has not been used in road construction. A small sample on hand indicates that the deposit is composed of flint, quartz, and limestone pebbles, with some sand and calcareous dust. The gravel is rather small in size, having no pebbles over ¾ in. in diameter.

Nolan County

The limestones in this county are comparatively soft and not suited for anything except the lightest kind of traffic. The results of two tests made by the Office of Public Roads at Washington, on limestone from this county, show about the quality of material to be found:

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	----	159	2.56	6.2	6.4	13.7	5	21	------
2	----	159	1.67	6.2	6.5	13.3	4	Fair	------

No. 1. This limestone was found at Maryneal, Texas, and the test was made by the Office of Public Roads, number 4327.

No. 2. This limestone was found at Sweetwater, Texas, and the test was made by the Office of Public Roads, number 4532.

A deposit of sand and gravel is located at Wastella, 1 mile from the Roscoe, Snyder, and Pleasanton Railroad, 16 miles west of Sweetwater. The deposit belongs to W. J. Turner of Wastella and there is no equipment on hand for the operation of the pit. It is said to be a large deposit, but with considerable overburden. A small sample on hand is composed of rounded and irregular pebbles of flint and quartz, with rather fine quartzitic sand and some calcareous material. The sample appears to have been washed.

Parker County

A deposit of gravel 2 miles west of Garner, and 300 yds. north of the Mineral Wells and Northwestern Railroad, is owned by J. C. Maddox, Snow and Ed Hall, all of Garner, Texas. The M. W. & N. W. Railroad runs within 300 yds. of the deposit, but there is no special equipment for loading on hand. It has been used on 2 miles of road in Parker County.

Palo Pinto County

There are several deposits of graded limestone to be found in this county. Tests have been made as follows:

Sp. Gr.	Wt. per cu. ft. Solid	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
2.65	165	0.54	4.4	9.2	12.5	7	93	8,425

This limestone (siliceous) was found at Mineral Wells, the owner being J. C. Burch, Mineral Wells, Texas. The test was made at the request of the Commissioners' Court, through the Commercial Club, Mineral Wells, Texas. The results show that this rock is low in hardness and toughness, with medium resistance to wear, very good cementing value and low resistance to compression. It is recommended for medium traffic, bituminous roads or light traffic water-bound construction. Sample No. 2484.

The Mineral Wells Crushed Stone Company operates a quarry and crushing plant, 8½ miles northwest of Mineral Wells on the Weatherford, Mineral Wells and Northwestern Railroad. During 1916 this plant produced 75,000 tons with a daily output of 500 tons, and this material when tested as a road material, gave the following results:

Sp. Gr.	Wt. per cu. ft. Solid	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
2.58	161	----	4.1	9.8	11.8	5	----	10,470

The test shows that this rock is low in hardness and toughness, has medium resistance to wear and fair resistance to compression. It is satisfactory only for light traffic, water-bound macadam roads, or possibly for bituminous roads having medium traffic.

The material has been used in road work in Dallas, Palo Pinto, Rockwall, McLennan, and Tarrant counties, while it has been used in most of the cities in the northern portion of the state.

Other tests in this material indicate that the quarry produces various qualities of stone, some harder than others, as follows:

No.	Sp. Gr.	Wt per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Crushing strength lbs. per sq. in
1	2.70	169	.15	----	---	----	----	----	16,000
2	2.61	165	.06	----	---	----	----	----	14,000

Tests made on this stone as a concrete aggregate show it to be quite satisfactory for this purpose, producing a concrete with a compressive strength of over 3,000 pounds per square inch, at 28 days

Polk County

In this county considerable gravel and sandstones are found. Most of the sandstones, however, are not uniform in texture and unsuited for road construction.

A gravel pit in the eastern end of the town of Onalaska has been used for railroad ballast by the M. K. & T. Railroad, as the Beaumont and Great Northern branch of this railroad runs through this town. An extended deposit of gravel, consisting mostly of rounded pebbles of flint and jasper, averaging about ¾ in. in diameter, is found. It is located on the farm of Mr. Wiley Hood in the northeastern corner of the Thomas Cartwright League in the hill covering about 5 or 6 acres. This deposit is west of Livingstone, in the southern part of the county and extends also to the farm of A. T. Watts, the northwest corner of the John Lindsay League. This deposit of gravel is accessible to the lumber train of Thompson Bros. Lumber Co., connecting at New Willard with the Houston, East and West Texas Railroad. On the Hood Place, a well showed that the gravel extended down 36 ft., having more clay in it as the bottom was approached. On the A. T. Watts farm a prospect hole showed the gravel to be about one-half flint gravel with pebbles varying in size from 2 in. to ½ in., and the other half, sand clay. At another place on the Watts farm, gravel was found 4 ft. below the surface, with a depth of 5 ft. The Watts gravel is about ½ mile from

Thompson Bros. Lumber Company's tram at a point 5 miles from New Willard.

There is a 15 ft. deposit of sandstone on the top of the hill at Moscow, which, however, is capped with sand-clay and gravel, making it somewhat difficult to procure. The shipping facilities for this material would be the Houston, East and West Texas Railroad.

On a hill 20 ft. or more high, directly west of mile-post 92, on the Houston, East and West Texas Railroad, is a deposit of sandstone. The surface is covered with large blocks of the rock. In the region between the M. K. & T. Railroad, north of Chester and the bottom lands of the Neches River, is a deposit of sandstone. The nearest shipping point for this material, however, is at Chester, some little distance away. A harder grade of sandstone forms the hills south of the Laurella siding. The material could be shipped by the Houston, East and West Texas Railroad. At Clarke, on the M. K. & T. Railroad, 18 miles from Corrigan, is a deposit of sandstone which is worked by the Southwest Texas Quarry Company, the owner being T. E. Danziger, Beaumont, Texas. In 1916, about 18,000 tons were produced, and it is estimated that with the present equipment, a production of 200 tons per day can be maintained. A small sample on hand indicates that the sandstone is rather soft, with occasional hard fragments. It should be satisfactory as a foundation course or in bituminous construction under light traffic. Another deposit of sandstone, quartzite, and semi-quartzite is located at Stryker, 5 miles east of Corrigan on the M. K. & T. Railroad. The Texas Grading Company of Houston owns the deposit, and it is reported that it is possible to produce from 3 to 4 cars of crushed stone daily. There is a crushing and screening plant already on hand, and it could be put into operation on short notice. The material has been used in the Harris County road work and also for the Sabine Pass jetty work. There are several more deposits of sandstone to be found around Corrigan. In the third cut south of that town, on the Houston, East and West Texas Railroad, an old quarry still exists. This material is a fine textured sandstone and it is about 11 ft. thick. It could be easily shipped as it is on a spur of the railroad. While only a few samples of

sandstone from this county have been examined, it is believed that most of the standstones are rather soft and friable, and therefore would not make satisfactory road material. Some samples, however, show indications of making very fine cut stone material for building construction. The main question regarded their suitability for this purpose, is whether or not they can be found to run uniform in texture and free from iron stain.

Presidio County

This county, like most of the West Texas counties, has abundant road material. However, the necessity for good road material is not felt at this time. While there are numerous gravel deposits, the most conspicuous road materials are the volcanic rocks, although sandstones and limestones are also found.

A gravel deposit worth nothing is found at the foot of the Chiati Mts. in the Rio Grande Valley in the vicinity of Shafter. In the southern Davis Mountains and northwest of Marfa, are sandstones and limestones having various degrees of weathering. In numerous places in the Fresno Canyon are found andesites, some of which are solid and hard, while others are very porous. In the Southern Davis Mountains are also found flinty, siliceous stones in the Marble Hills, extending from the former Barrel Springs Station on the old El Paso-Ft. Davis stage-line, to about 2 miles northeast. There are a number of vesicular and dense lavas with much conglomerate, found in the Tierra Vieja, Capote, and Chinati Mountains, also between the town of Marfa and the Chinati Mountains, as well as in the tributary water courses of the Cibolo Creek south of Sabocite and below Humphris' sheep camp. Many basalts are also found in the Tierra Vieja and Capote Mountains. In the Sierra Bofecillos and Sierra Refugio, in the southeast corner of the county, are located lavas of rhyolite, pit-stone, basalt, trachyte, and augite-andesite. Also in the Tierra Vieja Mountains and at Chispa Summit in the Chinati Mountains, are syenite-porphyry, basalt, and rhyolite. North and northwest of Shafter, in the Chinati Mountains are granites, diorites, lavas, and much altered diabases.

Red River County

One sample of limestone tested from this county was found along the public road near Clarksville. The sample of this argillaceous limestone was sent by Clarence Hocker of Clarksville, Texas, and when tested resulted as follows:

Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
2.15	134	2.11	12.0	3.3	----	3	137	1,920

The test shows that this is a very soft rock, with very low toughness and resistance to wear, excellent cementing value and very low compressive strength. The material is much too soft to be recommended in road construction. It is not recommended for concrete.

Reeves County

A gravel pit in this county is owned by Reeves County and also the Pecos Valley Southern Railroad. It is located about 26 miles south of Pecos on the P. V. S. Railroad main line. The production can be maintained at about 800 tons per day, while in 1916, there was used as much as 52,500 tons. The gravel at Saragosa has been used on the Reeves County roads and has been tested with the following results.

MECHANICAL ANALYSIS

	No. 1	No. 2	No. 3
Material retained on the 2-inch sieve	0	0	0
Material retained on the 1-inch sieve	9.9	14.1	25.4
Material retained on the ½-inch sieve	40.9	43.2	63.9
Material retained on the ⅛ inch sieve	74.5	62.0	83.0
Material retained on the .033-inch sieve	77.6	65.3	84.7
Material retained on the .0116-inch sieve	81.0	70.3	86.7
Material retained on the .0058 inch sieve	83.9	76.2	89.2
Material retained on the .0029 inch sieve	86.7	81.0	91.2
Material passing the .0029-inch sieve	12.7	18.8	9.1
Total	98.4	99.88	100.3
Cementing value on:			
Material over ⅛ inch in size	Poor	Fair	Fair
Material under ⅛ inch in size	Excell.	Excell.	Excell.
Material as received	Excell.	Fair	Good

No. 1. This gravel is composed of hard pebbles of flint and quartzite, some of which is sand and calcareous dust. This gravel should make a satisfactory material for gravel road construction.

No. 2. This is a well graded gravel composed of rounded pebbles of quartzite with considerable good bedding clay. The pebbles are also quite hard. From the results of this test, this gravel is highly recommended for gravel road construction.

No. 3. This gravel is composed of round pebbles of quartzite, a small amount of which is sand, and some good binding clay. The gravel will make a satisfactory road when completed, but due to a lack of sand it would require considerable traffic to bring the road to the desired compactness.

Rusk County

It has been reported that there is a deposit of sandstone one mile east of Overton, on the main public road. The owner is Joe Lee, Route 4, Box 3, Overton, Texas, and the deposit is located one mile east of the I. & G. N. Railroad tracks at Overton. A sample from this deposit is composed of flat fragments of sandstone, all of which are about 1½ inches in breadth, some being soft and others hard. It is not a first class road material.

A deposit of gravel belonging to W. C. Buford, is located one mile north of Henderson Courthouse on the Longview Road. A sample from this deposit has been tested as follows:

MECHANICAL ANALYSIS

	No. 1
Material retained on 2-inch sieve	3.9
Material retained on 1 inch sieve	15.6
Material retained on ½ inch sieve	53 9
Material retained on ⅛-inch sieve	92 0
Material retained on .033 inch sieve	95.8
Material retained on .0116 inch sieve	96.5
Material retained on .0058 inch sieve	97.3
Material retained on .0029 inch sieve	98.4
Material passing the .0029 inch sieve	0
Total	99.2
Cementing value on:	
Material over ⅛ inch in size	Good
Material under ⅛ inch in size	Fair
Material as received	Fair

This material consists of fragments of ferruginous sandstone, free

from sand and clay. The material will require an addition of considerable sand and clay to make a satisfactory road material.

A deposit of ferruginous sandstone, owned by Bruce Hamlett, is located 2½ miles northwest of Henderson, on the I. & G. N. Railroad, and has been tested as follows:

Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
2.85	178	2.28	5	8	14.9	2	33	25,750

This sample of ferruginous sandstone was sent in by O. G. Vinson, Henderson, Texas. It is a medium hard rock, with medium resistance to wear, very low toughness, good cementing value and high resistance to compression. This rock should be satisfactory for bituminous road construction or as a railroad ballast. Due to its toughness, it could not be recommended for plain macadam construction.

San Augustine County

In the southwestern part of this county, there is much ferruginous sandstone, which would make good road material. In the cut at mile post 666, of the St. Louis Southwestern Railroad, is a deposit of ferruginous-cemented hard conglomerate, with pebbles of quartz, chert, and silicified wood.

Just east of the channel of Bayou Attoyas, on the Huntington-Hemphill Road, are located bluffs a hundred feet or more in height. These bluffs are covered with ferruginous-cemented gravel of quartz, chert, and silicified wood pebbles. The shipping facilities are at Broaddus or Monterey, on the St. Louis Southwestern Railroad, approximately 3 miles from the deposit.

A deposit of gravel is found in the vicinity of White City on the St. Louis Southwestern Railroad and still another deposit of iron ore and ferruginous sandstone is located in the vicinity of the Ironosa Postoffice, with shipping facilities at Blandlake, some distance from the deposit on the Gulf, Colorado, and Santa Fe Railroad.

San Jacinto County

Gravel has been found in this county in several places. There is a deposit on the divide between the Trinity and San Jacinto drainages between Oakhurst and Cold Springs, with shipping facilities on the M. K. & T. Railroad to the north, the I. & G. N. Railroad to the west, the H. T. & W. T. Railroad to the east. A second deposit of gravel and sand, locally cemented with iron oxide, is found in the high ridges in the vicinity of Cold Springs, but it is 11½ miles from Shepherd on the Houston, East and West Texas Railroad. Near Westcott and Normanville about 4 miles west of the H. E. & W. T. Railroad is another deposit of gravel. Still another is located 4 miles southwest of Shepherd on the Evergreen Road, adjoining land owned by Mr. Bird of Bay City, Texas. This gravel consists of coarse, brown sand matrix, and is owned by C. B. Uddell (Treasurer of the Southern Pacific Lines, Houston, Texas). The shipping facilities are at Shepherd on the H. E. & W. T. Railroad.

The Urbana Gravel Co. of Houston, Texas, operates a plant in this county taking gravel and sand from the San Jacinto River. This gravel has been tested as a concrete aggregate. If screened it is a satisfactory concrete aggregate.

San Saba County

There is a deposit of sand, concrete gravel, and fine gravel and clay, 3 miles west of San Saba on the Santa Fe Railroad. The pit is owned by William Scott, San Saba, Texas, and the chief output is concrete sand and gravel. There is no special equipment and the pit is 300 yds. from the Santa Fe siding.

Shackelford County

A deposit of limestone is located 7 miles west of Albany on the M. K. & T. Railroad. It is owned by the Central Quarry Company, R. L. Newman, Mgr., Albany, Texas, and has shipping facilities on the M. K. & T. Railroad. A large quantity of this stone was used for ballast on the M. K. & T. Railroad, but at present the quarry is not in operation.

A deposit of clay quartz gravel is found on the right side of the Clear Fork of the Brazos River, 6 miles below Fort Griffin, 17 miles from a railroad. The gravel is not worked at the present time.

Smith County

In this county there is a deposit of limestone located 12 miles north of Tyler and 7 miles east of Lindale, Texas. Mrs. Eliza Weir, Tyler, Texas, is the owner of the deposit, which has no shipping facilities.

Stephens County

On the main line of the Texas Pacific Railway, near Odessa, Texas is found a deposit of limestone, which is owned by J. T. McElroy, Odessa, Texas. With the present equipment, 800 tons per da yare produced. The shipping facilities are on the main line of the Texas Pacific Railway, and the material has been used on the roads in Dallas, Tarrant, Denton, and McLennan counties.

Tarrant County

A deposit of sand and gravel is located 12 miles east of Ft. Worth, near New Bedford and 1½ miles east of Ft. Worth, and 1½ miles from the railroad. The owner is J. C. Martin, 903 Cannon Ave., Ft. Worth, Texas.

The Trinity Gravel Company owns a deposit 6 miles east of Ft. Worth. This material has been tested as follows:

MECHANICAL ANALYSIS

	No. 1
Material retained on the 2-inch sieve	0
Material retained on the 1-inch sieve	20.52
Material retained on the ½-inch sieve	48.90
Material retained on the ⅛-inch sieve	61.22
Material retained on the .033-inch sieve	72.74
Material retained on the .0116-inch sieve	97.35
Material retained on the .0058-inch sieve	99.45
Material retained on the .0029 inch sieve	99.58
Material passing the .0029-inch sieve	0.11
Total	99.69

The tests show that this material consists of rounded fragments of limestone with some flint and considerable calcareous sand. Specific gravity 2.50. One cubic foot weighs 128 pounds packed.

Concrete tests of this sample were made on one 6″ x 8″ cylinder proportions 1 : 8 by weight, 1 : 6 by volume. Stored under water and tested at the end of 28 days, it had crushing strength of 2,760 pounds per square inch.

Tom Green County

A gravel conglomerate is found in the city of San Angelo, Texas, on city property. Approximately 20 cu. yds. have been produced per hour; however, the deposit has just been opened. The shipping facilities are from either the G. C. & S. F., or the K. C. M. & O. railroads, about 1½ miles away This gravel has not been used, but a small sample indicates that this is a fairly hard conglomerate and would need crushing before it could be used.

Travis County

This county, lying in the centre of the State, and being the seat of the State Capitol, is in need of good roads. Like many of the adjacent counties, road material is quite plentiful and of a generally good character.

The rock predominating is limestone, generally rather soft in character and unsuited for the heavy traffic roads of modern times. Occasionally some very good ledges are found which will support the average traffic, but most of the limestone is soft and unsuitable.

The nephelite basalt is a trap rock found protruding in a knob above the surrounding limestone not far from Austin at a place named Pilot Knob. It is an excellent road-building material for the heaviest traffic, being hard, tough, and with a high resistance to wear. As a commercial possibility it would require a large investment and consequently a ready market. Perhaps when the State develops to such an extent that a large market is available for such material, it will be developed and placed within the reach of local road builders. One flint tested proved to be hard enough for road construction, but material of this

nature has not proven of much value, because of its poor binding qualities in water-bound macadam and it does not seem to interlock in a bituminous road.

Gravels, however, are plentiful, especially in the valley of the Colorado River. In this locality, they are mostly composed of flint, quartz, and limestone pebbles, with considerable sand and a good binding clay. While these are excellent gravels for a top course, they contain a little too much sand to be considered as excellent material. For surface treated gravel roads the limestone gravels are the best as they contain a much larger proportion of pebbles between ¼″ and 2″ in size to take the wear of traffic. These larger stones, furthermore, provide a much better surface for a bituminous material to adhere to than do the sand clay gravels.

The soft, chalky limestone underlying much of this county is of no value as a road material in any condition, except perhaps as a sub-base in its natural bed.

A large number of tests has been made of materials of this county, results of which are given herewith:

No.	Weight per cu. ft.	Water absorbed per cu. ft.	French coefficient of wear	Hardness	Toughness	Cementing Value	Compression lbs. per square inch
				Trap Rock			
1	200	0.37	24.7	19.0	28	35	46,660
				Limestone			
2	159	2.90	14.4	14.9	9	39	16,275
3	168	0.81	13.7	14.9	5	26	13,350
4	165	1.29	11.7	14.5	6	39	14,050
5	162	2.06	12.6	13.8	5	26	10,720
6	165	1.34	11.9	12.8	7	39	13,050
7	162	2.78	10.9	15.2	7	15	15,000
8	165	0.77	10.2	15.3	5	39	18,225
9	162	1.41	10.2	15.1	5	39	15,620
10	165	0.89	10.9	15.4	4	16	15,725
11	165	1.43	9.4	14.5	5	50	15,350
12	165	1.23	10.8	14.4	5	23	13,875
13	153	3.51	10.9	10.2	4	20	10,450
14	165	0.87	9.5	15.6	7	16	9,975
15	165	1.56	11.0	13.8	6	18	13,750
16	150	3.24	10.0	14.5	6	14	12,710
17	165	1.49	11.1	13.8	4	15	14,600
18	162	1.55	9.6	14.5	6	13	16,350
19	162	1.94	11.2	11.9	5	20	11,340
20	162	1.35	9.8	14.3	6	8	15,425
21	165	1.33	8.8	14.8	4	13	11,400
22	162	2.16	10.9	11.6	5	7	10,380
23	156	1.62	8.3	11.8	4	76	11,060
24	159	3.09	9.7	12.0	5	16	14,775
25	168	0.39	8.7	13.3	4	20	10,812
26	162	----	8.7	12.2	7	41	13,200
27	159	3.56	9.2	11.9	4	39	10,150
28	156	4.09	8.8	10.4	5	62	12,125
29	156	2.04	8.7	11.5	6	21	11,750
30	165	2.00	9.3	11.5	4	18	11,940
31	162	1.00	8.8	11.6	4	22	4,520
32	159	3.36	9.5	10.5	4	15	7,500
33	153	2.22	9.0	11.4	3	16	8,725
34	159	2.31	8.1	12.0	4	13	10,400
35	150	1.99	7.5	13.3	4	17	11,125
36	159	2.19	9.6	15.0	3	15	13,525
37	162	0.69	9 8	16.5	3	20	17,750
38	162	1.09	8.2	17.4	3	51	10,100
39	162	1.62	11.0	12.8	5	11	10.000
40	165	0.44	10.5	13.8	5	5	13,300
41	162	1.62	10.5	13.3	2	21	11,040
42	162	0.87	8.3	11.8	4	53	10,225
43	162	1.95	7.6	14.6	4	17	10,810
44	162	1.85	8.4	11.3	4	49	14,450
45	156	3.44	7.0	11.2	5	35	10,840
46	159	2.55	7.9	10.5	4	26	8,400
47	162	2.76	7.5	11.9	3	11	15,365
48	156	3.30	7.7	5.9	4	18	10,035
49	156	4.21	6.9	5.7	4	15	7.073
50	150	1.59	7.1	3.9	3	24	8,450
51	153	4.43	5.2	6.5	3	22	6,115
52	143	4.95	2.7	0.0	3	23	4,825
53	150	1.48	1.1	0.0	3	22	1,975
54	159	3.49	----	----	----	44	------

LOCATIONS AND REMARKS

No. 1. This is a nephelite basalt from Pilot Knob, 10 miles southeast of Austin and 5 miles from the I. & G. N. Railroad, in considerable quantities.

It is a very hard rock, with high toughness and resistance to wear cementing value and very high resistance to compression. It is an excellent material for heavy or very heavy traffic roads or streets, also for a concrete aggregate or railroad ballast. Lab. No. 2496.

Limestones

No. 2. From near Spicewood Springs, 7 miles northwest of Austin and within 1½ miles of I. & G. N. Railroad. This rock has medium hardness and resistance to wear, somewhat low toughness and good cementing value. It has high resistance to compression and should make a satisfactory material for waterbound macadam roads subjected to medium traffic or in bituminous construction. This rock should also make a good railroad ballast, or concrete aggregate when crushed to proper sizes. Lab. No. 1737.

No. 3. Located on Will Birkner's property, 1 mile west of I. & G. N. Railroad and about 12 miles from Austin.

This rock has medium hardness and resistance to wear, low toughness and good cementing value. It has a fairly high resistance to compression and is therefore recommended for medium or light traffic roads, but should be crushed in larger pieces than ordinary, due to the rather low toughness shown in the tests. Lab. No. 1937.

No. 4. Old ledge of Austin White Lime Co. at McNeil. The tests show the rock to have medium hardness and resistance to wear, low toughness, good cementing value and fairly high resistance to compression. It should be satisfactory for light or medium traffic roads, but due to its comparatively low toughness, larger sizes than ordinarily used should be used. Lab. No. 1958.

No. 5. From about 100 yards west of A. & N. W. Railroad and 1½ miles north of Watter's Park.

The rock is rather soft, with low toughness, medium resistance to wear and good cementing value. It has fair resistance to compression and is recommended for plain macadam roads having light traffic. Lab. No. 1941.

No. 6. About 1 mile north of Watter's Park on the A. & N. W. Railroad on the Georgetown Road. It is a rather soft rock, low in toughness, medium resistance to wear and good cementing value. It also has fairly high resistance to compression and is only recommended for light traffic roads. Lab. No. 1940.

No. 7. From old Michel Place (Bartholomew) about 3½ miles southwest of Austin, near Fredericksburg Road.

The rock has medium hardness and resistance to wear, low toughness, and fair cementing value. It has a fairly high compressive strength. The material should be satisfactory for macadam roads under medium or light traffic. Will make a good concrete aggregate when crushed to proper sizes. Lab. No. 1887.

No. 8. Sample taken from exposure at wagon-road crossing of I. & G. N. Railroad, first creek north of Duval section-house, and about 12 miles northwest of Austin.

With medium hardness and resistance to wear, low toughness, good cementing value and high resistance to compression, this stone should prove satisfactory in waterbound macadam roads subjected to medium traffic or in bituminous macadam roads. Should make a good railroad ballast. Lab. No. 1967.

No. 9. From the Wilson place, about 7 miles northwest of Austin, and 200 yards west of I. & G. N. Railroad.

A medium hard rock, with medium resistance to wear, low toughness, and good cementing value. It has fairly high resistance to compression. A satisfactory material for light or medium traffic, but due to its low toughness, larger pieces than ordinary should be used. Lab. No. 1971.

No. 10. Taken from property of J. A. Patton, about 8 miles southwest of Austin, west of Fredericksburg Road near Oak Hill and about 4 miles west of I. & G. N. Railroad.

A medium hard rock, low in toughness, medium resistance to wear, and fair cementing value. It has fair resistance to compression and should be satisfactory for a road having medium or light traffic. Lab. No. 1837.

No. 11. From near Pease Park Road on east side, Austin. The rock has medium hardness and resistance to wear, low toughness and good cementing value, and fairly high resistance to compression. This rock should prove satisfactory for light or medium traffic roads but due to its low toughness larger size pieces should be used. Lab. No. 1975.

No. 12. From the old Walsh quarry near end of I. & G. N. track, Austin Branch to Lake Austin. The rock has medium hardness, and resistance to wear, low toughness and fair cementing value and fairly high resistance to compression. Not a satisfactory road material, except for light traffic. Lab. No. 1784.

No. 13. Locality from ¼ to ½ mile south of Duval section-house of I. & G. N. Railroad and about 12 miles northwest of Austin.

This is a soft rock, with medium resistance to wear, low toughness, and fair cementing value. It also has fair resistance to compression. It is not recommended as a road building material except for light traffic. Lab. No. 1966.

No. 14. Bird Ranch, about 10 miles northwest of Austin and about 200 yards west of I. & G. N. Railroad. The rock has medium hardness, and resistance to wear, low toughness and fair cementing value. It has low compressive strength. Suitable for light traffic waterbound macadam roads. Lab. No. 1964.

15. About 6 miles from Austin on upper Manchaca Road, near Old Oak Hill railroad switch.

It is a rather soft rock, low in toughness, with medium resistance to wear and fair cementing value. It is recommended only for waterbound macadam construction under light traffic. Lab. No. 1933.

No. 16. Old Taylor quarry at lime kiln near I. & G. N. track to Austin dam, Austin.

This rock shows medium hardness and resistance to wear, low toughness and fair cementing value. It has fairly high resistance to wear. Recommended for light traffic in waterbound macadam or in bituminous macadam construction. Lab. No. 1785.

No. 17. Old Johnson quarry at Deep Eddy, Colorado River west of Austin.

A soft rock, with medium resistance to wear, low toughness, fair cementing value and resistance to compression. Will do for light traffic roads. Lab. No. 1786.

No. 18. Located 1 mile from Oak Hill, near Fredericksburg Road and about 4 miles west of I. & G. N. Railroad.

A medium hard rock, low in toughness, medium resistance to wear, fair cementing value but high resistance to compression. A satisfactory material for water bound macadam roads having light traffic or in bituminous construction. Lab. No. 1838.

No. 19. From property of Will Birkner, 1 mile west of I. & G. N. Railroad and about 12 miles from Austin.

A soft rock, low in toughness, with medium resistance to wear and fair cementing value. It has a fair resistance to compression. Recommended only for light traffic roads. Lab. No. 1936.

No. 20. Old Zilker quarry, opposite Barton Springs, southwest of Austin.

A rock with medium hardness and resistance to wear, low toughness, poor cementing value, but with fairly high compressive strength. Will do for light traffic roads. Lab. No. 1875.

No. 21. About 3¾ miles west of Austin on Bee Cave Road. It has medium hardness and resistance to wear, low toughness and fair cementing value and resistance to compression. Recommended only for light traffic roads. Lab. No. 1900.

No. 22. From 3 miles west of Austin on Bee Cave Road.

A soft rock, with medium resistance to wear, low toughness and poor cementing value. It has a fair resistance to compression. Not recommended as a road material except perhaps in bituminous macadam. Lab. No. 1899.

No. 23. Hamilton Place, 8 miles northwest of Austin on Burnet Road, and about 800 yards west of I. & G. N. Railroad.

The tests show this to be a soft rock, low in toughness with medium resistance to wear, good cementing value and fair resistance to compression. Not recommended for road construction except for light traffic. Lab. No. 1960.

No. 24. From north end of exposure at west side of Shoal Creek, near Pease Park Road, Austin.

A rather soft rock, low in toughness, with medium resistance to wear, fair cementing value and fairly high resistance to compression. Only satisfactory for light traffic. Lab. No. 1977.

No. 25. Bear Creek, a short distance above junction with Onion Creek and about ½ mile east of the I. & G. N. Railroad and 1 mile southeast of Manchaca.

A rather soft rock, low in toughness, with medium resistance to wear and fair cementing value. Not recommended for road construction except for light traffic. Lab. No. 1841.

No. 26. Railroad cut of I. & G. N., about 3½ miles southwest of Austin.

An argillaceous limestone having low hardness and toughness, fair resistance to wear and also compression and good cementing value. Light traffic roads or as a railroad ballast. Lab. No. 2457.

No. 27. About 1 mile west of I. & G. N. Railroad on south side of county road near Camp Mabry.

A soft rock, low in toughness, with medium resistance to wear and good cementing value. Light traffic roads. Lab. No. 1836.

No. 28. Hamilton Place, 8 miles northwest of Austin on Burnet Road, and about 800 yards west of I. & G. N. Railroad.

A soft rock with low toughness, medium resistance to wear, good cementing value and fair resistance to compression. Not recommended as a road material, except for light traffic.

No. 29. From Hamilton Place, 8 miles northwest of Austin on Burnet Road, and about 1000 yards west of I. & G. N. Railroad.

A soft rock, having low toughness, medium resistance to wear and fair resistance to compression and cementing value. Not a road material except for light traffic roads. Lab. No. 1961.

No. 30. From ravine west of I. & G. N. Railroad and north of street car line to dam, near Austin. A rather soft rock, low in toughness, medium resistance to wear and fair cementing value. It has fair resistance to compression. Not a road material, except under light traffic. Lab. No. 1973.

No. 31. Property of E. F. Elliott, about 8 1/3 miles northwest of Austin, and about 300 yards west of I. & G. N. Railroad.

A soft rock, low in toughness and with medium resistance to wear and fair cementing value. It has a very low resistance to compression. Not recommended as a road material, except for very light traffic. Lab. No. 1962.

No. 32. About ¾ mile west of Manchaca on Bear Creek. A soft rock low in toughness, with medium resistance to wear, fair cementing value, and low resistance to compression. Not recommended except for light traffic roads. Lab. No. 1935.

No. 33. From Barton Creek, about 1 mile above Barton Springs.

This is a soft rock with medium resistance to wear, fair cementing value. Satisfactory only for very light traffic roads. Lab. No. 1834.

No. 34. Barton Creek about 1 mile above Barton Springs southwest of Austin.

A rock with low hardness, toughness, medium resistance to wear, fair cementing value and low resistance to compression. Not recommended for road construction except for light traffic. Lab. No. 1835.

No. 35. One mile north of Manchaca and about ¼ mile west of I. & G. N. Railroad on Slaughter Creek.

A rock of variable hardness, low in toughness and resistance to wear, and fair cementing value. Will do for light traffic roads. Lab. No. 1843.

No. 36. Payton Place, about 7¾ miles northwest of Austin and about 500 yards west of I. & G. N. Railroad. A rock of medium hardness and resistance to wear, very low toughness, fair cementing value and resistance to compression. Lab. No. 1970.

No. 37. Location near Spicewood Springs, 7 miles northwest of Austin and within ½ mile of I. & G. N. Railroad. A medium hard rock, with medium resistance to wear, low toughness, and fair cementing value. It has a high resistance to compression. Due to its low toughness, this rock is not recommended for road construction. Lab. No. 1788.

No. 38. Property of Frank Cheatham, about 9 miles northwest of Austin on Burnet Road, and about 1,000 yards west of I. & G. N. Railroad.

A hard rock, with medium resistance to wear, very low toughness and good cementing value. It has fair resistance to compression. Due to its very low toughness, this rock is not recommended for road construction. Lab. No. 1963.

No. 39. W. E. McNeese land, about 4 miles south of Round Rock on Georgetown road, 1 mile east of A. & N. W. Railroad.

A soft rock, low in toughness with medium resistance to wear and fair cementing value. It has fair resistance to compression. Will do for foundation course or in bituminous macadam. Lab. No. 1943.

No. 40. Old Zilker quarry, opposite Barton Springs, southwest of Austin.

A soft rock, with medium resistance to wear, low toughness and poor cementing value. It has fair resistance to compression, but is not recommended for road construction. Lab. No. 1874.

No. 41. Marshall quarry, 6 miles west of Austin (Marshall goat ranch).

A soft rock, with medium resistance to wear, low toughness, fair cementing value and resistance to compression. Not recommended as a road building material. Lab. No. 1902.

No. 42. About ½ mile south of Duval section-house on I. & G. N. Railroad, and about 12 miles northwest of Austin.

A rock low in hardness and toughness with medium resistance to wear, good cementing value and fair resistance to compression. Not recommended for road construction. Lab. No. 1965.

No. 43. About 5 miles southwest of Austin and ¾ miles west of I. & G. N. Railroad along Dripping Springs Road.

A medium hard rock, low in toughness and resistance to wear and fair cementing value. Not recommended for road construction. Lab. No. 1839.

No. 44. J. D. Cahill's land, about ¾ miles south of McNeil station, I. & G. N. Railroad, and about 200 yards from railroad.

The tests show this to be a soft rock, with medium resistance to wear, low toughness and good cementing value. It has fair resistance to compression. Not recommended as a road building material but should do well for railroad ballast. Lab. No. 1969.

No. 45. Within city limits of Austin, about 200 yards west of I. & G. N. Railroad on Fredericksburg Road.

A soft rock, low in toughness and resistance to wear, but with good cementing value. Will do for very light traffic roads. Lab. No. 1840.

No. 46. West side of Shoal Creek, near Pease Park, Austin.

This is a soft rock low in toughness and resistance to wear and good cementing value. It has low compressive strength. Not recommended as a road- building material. Lab. No. 1976.

No. 47. On Austin-Manchaca Road, about ¼ mile west of I. & G. N. Railroad and about 400 yards from Slaughter Creek.

The tests show this to be a soft rock, low in toughness and resistance to wear and fair cementing value. Not recommended for road construction. Lab. No. 1844.

No. 48. Eight miles south of Austin on Manchaca Road.

A soft rock, low in toughness and resistance to wear and fair cementing value. It has fair compressive strength Not recommended as a road building material. Lab. No. 1934.

No. 49. Bear Creek, a short distance above junction with Onion Creek and about ½ mile east of I. & G. N. Railroad and about 1 mile southeast of Manchaca Road.

A soft rock, low in toughness, resistance to wear and compressive strength and fair cementing value. Not recommended as a road building material. Lab. No. 1842.

No. 50. On Walnut Creek, northeast of Duval section-house, I. & G. N. Railroad, and about 12 miles northwest of Austin and about 150 yards east of the railroad.

The tests show this to be a soft rock, low in toughness and resistance to wear, fair cementing value, but low compressive

strength. Not recommended as a road building material nor as a railroad ballast. Lab. No. 1968.

No. 51. About 500 yards up Onion Creek from bridge on Creedmoor road.

This is a soft rock, low both in toughness, resistance to wear, and compressive strength, and of fair cementing value. Not recommended as a road building material. Lab. No. 1860.

No. 52. Near Duval section-house and about 200 yards west of I. & G. N. Railroad.

A very soft rock, with very low toughness and resistance to wear and fair cementing value. Not recommended as a road material. Lab. No. 2259.

No. 53. E. Martin's quarry on Onion Creek about 1 mile above bridge on Creedmoor Road.

This rock has very low hardness, toughness and resistance to wear, with fair cementing value and is therefore not recommended for road construction. Lab. No. 1861.

No. 54. Georgetown-Round Rock Road, 1¾ miles north of Watter's Park, A. & N. W. Railroad on property of John Brookman. Not recommended as a road material. Lab. No. 1942.

Gravels in this county which have been tested are as follows:

MECHANICAL ANALYSIS

	Per cent of material retained on:						Passing	Cementing Value on Material		
No.	2-in. sieve	1-in. sieve	½-in. sieve	⅛ in. sieve	.0016 in. sieve No. 48	.0029-in. sieve No. 200	.0029 in. sieve No. 200	above ⅛-in. sieve	below ⅛ in. sieve	as received
1	11	27	42	71	86	88	12	poor	good	fair
2	0	10	31	68	90	93	7	poor	poor	poor
3	5	21	35	66	87	94	6	poor	good	fair
4	0	11	30	73	92	96	4	poor	fair	poor
5	3	12	30	70	94	97	3	poor	poor	poor
6	8	20	40	76	97	97	3	poor	fair	poor
7	0	22	48	78	93	97	3	poor	poor	poor
8	0	13	37	79	97	98	2	poor	poor	poor
9	0	6	28	67	89	94	6	poor	fair	poor
10	7	11	19	64	91	96	4	poor	poor	poor
11	12	28	40	63	81	86	14	poor	good	poor
12	14	26	52	83	95	96	4	poor	poor	poor
13	5	18	36	61	95	97	3	poor	poor	fair
14	5	12	39	64	83	88	12	poor	poor	poor
15	6	18	36	64	80	83	17	poor	excell.	fair
16	6	14	26	64	92	96	4	poor	fair	poor
17	8	16	30	63	93	96	4	poor	poor	poor
18	4	11	30	64	89	95	5	poor	poor	poor
19	0	9	27	50	87	93	7	fair	fair	fair
20	5	18	41	84	99	100	0	-----	-----	-----
21	0	2	12	40	85	89	11	poor	good	good
22	0	3	9	36	82	86	14	poor	good	fair
23	0	18	38	72	86	90	10	poor	good	fair
24	5	21	36	64	84	87	13	poor	excell.	poor
25	17	38	47	57	84	88	12	poor	excell.	good
26	5	16	43	69	81	85	15	poor	good	fair
27	0	9	36	66	80	84	16	poor	fair	poor
28	0	9	33	65	76	79	21	fair	excell.	good
29	0	14	26	56	88	92	8	poor	poor	poor
30	3	9	19	49	81	86	14	poor	fair	fair
31	0	6	23	58	80	86	14	poor	good	poor
32	0	11	24	51	68	72	28	poor	excell.	fair
33	0	2	5	17	78	88	12	poor	fair	good
34	0	0	1	42	89	92	8	poor	fair	fair
35	42	80	100	--	--	--	--	-----	-----	-----
36	0	6	11	43	88	90	10	poor	fair	fair
37	9	11	22	48	67	73	27	fair	excell.	excell.
38	23	26	34	53	95	98	2	poor	poor	poor
39	0	5	13	34	82	86	14	poor	fair	fair
40	5	12	15	41	79	82	18	good	excell.	excell.
41	0	6	13	35	76	83	17	poor	fair	good
42	0	5	9	30	73	79	21	poor	excell.	excell.
43	0	1	1	27	73	77	23	poor	excell.	excell.
44	0	1	9	36	83	88	12	poor	excell.	fair
45	0	0	14	47	77	79	21	poor	fair	good
46	0	13	28	47	60	65	35	poor	good	fair
47	0	16	40	63	72	77	23	poor	fair	fair
48	0	9	7	30	67	79	21	poor	fair	fair
49	0	0	4	41	83	87	13	fair	good	fair
50	0	3	8	31	73	84	16	fair	good	fair
51	0	5	9	24	63	67	33	fair	excell.	excell.
52	0	6	13	30	68	84	16	poor	good	fair

No. 1. Gravel from the Bledsoe pit 5 miles south from Austin on the Lockhart road.

The gravel is composed of more or less rounded fragments of

limestone with some chert, all well graded and it should be satisfactory for road construction. Lab. No. 1898.

No. 2. Summerow pit about 1 mile below the crossing of the San Antonio Road on Onion Creek, about 10 miles south of Austin.

Gravel sample is composed of rounded pebbles of limestone. It should make a good gravel road. Lab. No. 1894.

No. 3. Pit on land of Mrs. Stokes, Webberville Road, 1½ miles from Austin.

Sample composed essentially of rounded pebbles of flint and limestone with some quartz. It is well graded and should prove satisfactory as a road building material. Lab. No. 2177.

No. 4. County pit on south bank of Onion Creek on Lockhart Road, 8 miles south of Austin.

Sample is composed of more or less rounded fragments of a hard limestone, fairly well graded. It should be satisfactory gravel for road construction. Lab. No. 1890.

No. 5. Zilker pit, near Barton Springs, southwest of Austin.

Gravel is composed of rounded fragments of a hard limestone. It should prove satisfactory as a material for gravel road construction. Lab. No. 1876.

No. 6. County pit, on Onion Creek bridge, Creedmoor Road.

Gravel is composed of more or less rounded fragments of a hard limestone well graded. Should make a satisfactory road material. Lab. No. 1859.

No. 7. Pit on land of Chas. Davidson, Austin-Bastrop Road, east of Onion Creek and about 9 miles from Austin.

This sample is composed of rounded pebbles and a hard limestone fairly well graded and should prove quite satisfactory for gravel road construction. Lab. No. 1873.

No. 8. From the T. T. Waggoner Place, north side of Onion Creek, above crossing of San Antonio Road, about 10 miles south of Austin.

This material is composed of more or less rounded fragments of limestone with little fine material. Due to the soft nature of the pebbles this gravel is only recommended for light traffic roads. Lab. No. 1893.

No. 9. Sheppard pit, about 1 mile south of Del Valle store, near Creedmoor Road.

Gravel consists essentially of more or less rounded pebbles of limestone, of medium hardness. It should make a satisfactory road material, though it will probably need considerable traffic to compact the surface. Lab. No. 1856.

No. 10. Pit of F. A. Heep about ½ mile to left of Station 550 on San Antonio Post Road.

Gravel is composed of limestone pebbles with considerable calcareous sand. Due to the considerable quantity of sand it will not make a very satisfactory road. Lab. No. 2352.

No. 11. From the Geo. Smith pit, 5 miles southwest of Austin on the Fredericksburg Road.

Gravel is composed of more or less rounded fragments of limestone with a considerable amount of fine material, but it should make a satisfactory gravel road. Lab. No. 1886.

No. 12. Pit of Heywood Barr opposite Station 429 on Austin-San Antonio Post Road.

Gravel sample is composed of rounded fragments of limestone with little fine material. It should prove satisfactory as material for gravel road construction. Lab. No. 2353.

No. 13. Bed of Colorado River at south end of bridge at Austin.

This gravel is composed of fragments of quartz, flint and limestone with considerable sand. A good aggregate for concrete, but to insure continued correct grading, it should be screened and remixed. Lab. No. 1855.

No. 14. Miller pit, 3 miles south of Austin.

Sample composed essentially of rounded fragments of limestone with considerable fine material. Should prove a satisfactory material for gravel road construction, however, a large percentage of pebbles between ½″ and 2″ in size should improve the gravel. Lab. No. 1882.

No. 15. Near St. Edward's College, 3 miles south of Austin on the Austin-San Antonio Post Road.

The gravel is composed of more or less rounded fragments of limestone with considerable fine material. It should make a very good road material. Lab. No. 1853.

No. 16. John Ash pit, 10 miles south of Austin.

The gravel is made up of more or less rounded fragments of fairly hard limestone, with little fine material. This gravel should prove satisfactory as a road building material, but better wearing qualities would result if the material contained more pebbles between ½″ and 2″ in size. Lab. No. 1892.

No. 17. From the Hale Place, 7 miles south of Austin, and about ½ mile east of the San Antonio Road.

The gravel is composed of rounded pebbles of limestone with considerable calcareous sand, and should make a satisfactory road gravel. Lab. No. 1891.

No. 18. Zilker pit on Johnson-Ft. Worth Road, near Bee Cave Road, close to Colorado River, 3 miles west of Austin.

Made up of more or less rounded fragments of limestone with considerable calcareous sand, and should be a satisfactory gravel road material. Lab. No. 1895.

No. 19. From a deposit about 1 mile west of Montopolis bridge, across Colorado River, near Austin.

The sample consists essentially of rounded fragments of limestone with some flint and quartz with a large amount of calcareous sand, more than is necessary but it is believed that it will be a

satisfactory material for gravel road construction. Lab. No. 1857.

No. 20. One mile up Onion Creek from San Antonio-Austin Post Road.

Gravel is composed of well rounded pebbles of hard limestone. It should make a good concrete aggregate topping for surface treatment if properly screened. Lab. No. 2355.

No. 21. Pit on property of Joe Hornsby, 9 miles southeast of Austin on the Webberville Road.

This sample consists of rather small rounded pebbles of flint, quartz, and some granite most of which is considered as sand with considerable good binding clay. While it is generally desired that a gravel have about 70 per cent pebbles larger than ⅛″, this material should make a good binder course due to its binding properties. Lab. No. 1872.

No. 22. Property of Judge Hamilton, 2½ miles east of Austin on Manor Road.

This is a sand clay gravel, composed of more or less rounded pebbles of quartz, feldspar, and flint with considerable sand and clay. A larger amount of pebbles over ⅛″ in size would be more desirable, but due to its good binding properties, this gravel should make a very good binder course. Lab. No. 1881.

No. 23. Bill Dunston pit, on Cameron road at Little Walnut Creek about 7 miles northeast of Austin.

Gravel is composed of rounded fragments of a soft limestone and therefore is only recommended for light traffic roads. Lab. No. 1878.

No. 24. Cullen pit on old Creedmoor Road, about 6 miles southeast of Austin.

It is composed of well graded rounded fragments of limestone having excellent binding properties. It is recommended for roads having light traffic. Lab. No. 1862.

No. 25. From the county pit, about 1 mile south of Montopolis bridge, across the Colorado River near Austin.

The sample is composed of more or less rounded pebbles of flint, quartzite, and chert with a large amount of sand and clay. With stones over 2″ removed this should make a satisfactory gravel road, and an excellent binder course due to its excellent binding qualities. Lab. No. 1858.

No. 26. Martin pit, on Buda Road between Manchaca and Onion Creek and south of Austin.

Gravel is composed of soft limestone fragments with a considerable amount of calcareous and fine material well graded. Due to the soft nature of the material, it is not recommended for road construction, except for light traffic. Lab. No. 1932.

No. 27. From pit on property of W. K. Beckitt, 6 miles south of Austin.

Consists essentially of rounded fragments of a soft limestone

with a large quantity of fine calcareous material. Due to the soft nature of the pebbles composing this gravel and the excessive amount of fine material, this gravel is not recommended for road construction, except for light traffic. Lab. No. 1884.

No. 28. J. Maxwell pit, on Cameron road, just across Big Walnut Creek, about 9 miles northeast of Austin.

The sample is composed of more or less rounded fragments of soft limestone and some shell. Due to the soft nature of the material making up this gravel and the large amount of fine material it contains it is not recommended for gravel road construction. Lab. No. 1879.

No. 29. Pit on University land, road to Austin dam. This gravel is composed essentially of more or less rounded pebbles of quartzite and flint with a large amount of sand. It contains too much sand and insufficient clay to make a good road material. Lab. No. 2130.

No. 30. From property of University of Texas, Austin. The sample consists of rounded pebbles of quartz and flint with some feldspar and a large amount of sand. Contains too much sand to be satisfactory as a road material. Lab. No. 2321.

No. 31. Pit on property of August Anson, on Cameron Road, at Buttermilk Creek, 6 miles northeast of Austin.

This sample is composed of rounded fragments of limestone, as a road material due to the soft nature of the pebbles and the small in size and with considerable fine material. Not recommended excellent amount of fine material. Lab. No. 1877.

No. 32. T. W. Medearis, 8 miles south of Austin on Lockhart Road.

Sample consists of rounded fragments of limestone with a large amount of fine material of a calcareous nature. It contains too much fine material to be a satisfactory road material. Lab. No. 1889.

No. 33. Roger's Hill, Webberville Road, about 7 miles southeast of Austin.

The sample consists of small rounded pebbles of quartzite and flint with some clay, practically all of which may be considered as a sand. It contains too much sand and too little larger pebbles to be satisfactory material for road construction. Lab. No. 1863.

No. 34. Pit near Insane Asylum, Austin.

This gravel would make a road satisfactory in wet weather, but rather dusty in dry weather, but lacks larger pebbles to support traffic. Lab. No. 1846.

No. 35. Taken from bed of Barton Creek, about 500 yards above Barton Springs south of Austin.

It is composed of rounded pebbles of hard limestone free from sand or clay. It should make an excellent concrete aggregate, but contains no binder to make it set up in road construction. Lab. No. 1854.

No. 36. Taken near Ft. Prairie, Webberville Road, about 5 miles southeast of Austin.

The sample is composed of pebbles of quartz, feldspar, and flint and a large amount of sand. The gravel should contain more larger pebbles to be satisfactory in road construction. The greater part of this sample is sand. Lab. No. 1864.

No. 37. Austin city pit on Washington Ave., Austin.

This is a sand clay material composed of rounded pebbles of granite quartzite, and flint with a large amount of calcareous sand and clay. It therefore contains too much sand and clay to be a satisfactory gravel for road construction. Lab. No. 1866.

No. 38. McCachern pit, 12 miles southeast of Austin, on Webberville Road.

This gravel is composed of more or less rounded fragments of limestone, flint, and quartz most of which is a sand. Not a satisfactory road gravel. Lab. No. 1870.

No. 39. Pit on Webberville Road, about 2 miles from Austin.

This is practically a sand, composed of small pebbles of quartz, flint, and limestone. It is not recommended as a road gravel, as it contains too much sand. Lab. No. 1865.

No. 40. Pit on land of Chas. B. Winn, about 1½ miles west of Austin, and about ½ mile west of I. & G. N. Railroad.

This is a sand clay gravel, consisting of more or less rounded pebbles of flint and quartz with considerable chert, most of which is a sand clay. Contains too much sand to be entirely satisfactory as a road gravel. Lab. No. 1897.

No. 41. Tadlock's pit near Camp Mabry about ¼ mile from I. & G. N. Railroad, Austin.

The gravel is composed of more or less rounded fragments of quartz, flint and some feldspar, practically all of which is small enough to be considered as a sand. This is a good binding gravel and should make a good binder course, but does not contain enough coarser pebbles to take the wear. Lab. No. 2313.

No. 42. From property of University of Texas, Austin.

Gravel is made up of rounded pebbles of quartz and flint with some feldspar most of which is sand and clay. The material contains too much sand and clay to make a good wear-resisting road. Lab. No. 2319.

No. 43. From University of Texas property, Austin.

Gravel is composed of rounded pebbles of quartz, and feldspar, practically all of which is a sand with some clay. Does not contain sufficient larger pebbles to carry the traffic without excessive wear. Lab. No. 2320.

No. 44. Property of W. N. Hessey, on Cameron Road, north of Austin city limits.

This is a sand clay gravel, composed of pebbles of quartz, flint, and feldspar with considerable clay. About 80 per cent of this material

is a sand and clay and it therefore would be considered as a sand clay road, and not a gravel road. Lab. No. 2323.

No. 45. From bank below wagon road leading from road to dam, to Hartkopf's dairy south of two story stone house.

Sample is composed essentially of rounded pebbles of quartz and flint with some feldspar. It is a sand clay gravel and would not be a suitable road material as it lacks the larger pebbles to carry the traffic. Lab. No. 2175.

No. 46. Bartholomew Pit, 4 miles southwest of Austin.

This gravel is composed essentially of rounded limestone fragments with some flint and considerable fine material of a calcareous nature. Contains entirely too much fine material to be satisfactory in road construction. Lab. No. 1855.

No. 47. E. C. Ratliffe pit, 3½ miles south of Austin.

Sample is composed essentially of more or less rounded fragments of soft limestone and a large amount of very fine material of a calcareous nature. This sample contains too much fine material to be recommended. Lab. No. 1883.

No. 48. Pit on Manor Road, 2 miles east of Austin.

This is a sand clay gravel composed of pebbles of flint, quartz, and feldspar with considerable clay and some calcareous material. It contains too much sand to be a satisfactory gravel road material. A satisfactory sand clay road could be constructed from this material. Lab. No. 1867.

No. 49. County pit, 4 miles east of Austin, on Manor Road.

A sand clay gravel composed of pebbles of quartz and feldspar with considerable clay. It would make a poor gravel road, but a good sand clay road. Lab. No. 1868.

No. 50. Littlepage's pit, 11 miles southeast of Austin on Webberville Road.

A sand clay gravel composed of more or less rounded pebbles of flint, quartz, and considerable good binding clay. A satisfactory sand clay but not gravel road material. Lab. No. 1871.

No. 51. Morgan Huling pit, Chicon St., near Rosewood Ave., Austin.

A sand clay material composed of flint and quartz pebbles most of which is a sand and considerable clay. Not a satisfactory gravel road material. Should make a satisfactory sand clay road. Lab. No. 1880.

No. 52. Pit ¼ mile beyond city limits, extension of Chinquapin Ave., east of Austin on property of Carl Hyltin.

A sand clay gravel, satisfactory as a sand clay material, but not gravel road material. Lab. No. 2207.

Trinity County

In general the gravel deposits in this county are thin. The flat divide between the Trinity and Neches rivers is a long cremate-margined sandy and gravelly plain. Around the margin the thicker mantles of gravel are on the tops and sides of the hills and ridges.

A deposit of gravel is found in the vicinity of Groveton with shipping facilities at Groveton on the M. K. & T. Railroad. On the east side of Mill Creek near the B. & G. N. (M. K. & T.) Railroad, extending for over one mile, is located a deposit consisting of quartzite and semi-quartzitic sandstone. The quarry on this deposit is owned by the Trinity Sand and Stone Company, Trinity, Texas, and the sandstone has been used by the U. S. Army Engineers, in the construction of locks and dams on the Trinity River. A spur from the railroad can be built down Mill Creek, and as the sandstone caps the bluffs, it can be quarried by gravity system. This stone would make a poor road material but would make a fairly satisfactory ballast.

Tyler County

The gravels located in this county are found in small deposits. Between Colmesneil and the top of the grade at Cina siding on the Texas and New Orleans Railroad, is a deposit of locally ferruginous-cemented gravel.

There are four deposits of sandstone reported from Tyler County. The first is found at the rapids on the Neches River, 12 miles east-northeast of Colmesneil and ½ mile below Smith's Ferry with shipping facilities at Burr's Ferry on the Browndell and Chester Railroad at Turpentine. This sandstone is locally semi-quartzitic, only medium hard and therefore very poor road material. A second deposit is found along the Burr's Ferry, Browndell and Chester Railroad, between the Neches and Angelina rivers and in the bluffs along the Angelina River. The shipping facilities are on the Burr's Ferry, Browndell and Chester Railroad. The sandstone is quartzitic and semi-quartzitic interbedded with clay. Much of it is exposed in railway cuts and vicinity. The texture varies from fine conglomerate to very

fine-grained sandstone. The degree of induration varies much from place to place. On the whole, it is from a poor to fair road material.

A third deposit of quartzitic and semi-quartzitic sandstone is found at Kyle's Quarry, two miles west of Aldridge and north of the Neches River, shipping facilities at Kyle Quarry station on Burr's Ferry, Browndell and Chester Railroad. The material has been used in the jetties of Sabine Pass. The main layer quarried is from 35 to 40 ft. thick, and carries local deposits of greenish clay, but the upper 10 ft. is not indurated enough to make crushed rock. The rock for its entire thickness makes up one massive bed and the workable portion is sufficiently brittle to break with sharp edges. It has from 10 to 12 ft. of overburden. It would make only a fair road material but could be used for ballast.

A fourth deposit of sandstone interbedded with clays has been reported. It is located, beginning from mile post 101, T. & N. O. Railroad, northward to Neches River beyond Rockland, where the hills and bluffs are capped with sandstone. This, however, is poor road material, though some of it might possibly be used for ballast.

Upshur County

A deposit of gravel owned by D. F. Crow, Gilmer, Texas, is located 8½ miles northeast of Gilmer and 5 miles east of Bettie, on the railroad.

Uvalde County

There is probably no other county in the state which has such an abundance of high quality road material. While it is a fact that there is little local market for this material for road construction, there have been two very successful commercial plants utilizing some of these natural materials. These plants are the Texas Trap Rock Company and The Uvalde Rock Asphalt Company. The former operates a crushed stone quarry at Knippa, producing a hard and tough basalt, which has been used extensively all over the state for road and street construction and a

concrete aggregate. The latter operates the deposit of natural rock asphalt below Cline. This rock asphalt is probably superior to any in the United States, from the fact that the body of the material is a limestone, which is said to be similar to rock asphalt used in Europe in the paving of the largest cities. The rock asphalts found in other parts of the United States are all sandstone rock asphalt, which have not proven as successful for paving construction as that with limestone base. This material has been used in many cities in this state. It is now being offered as a surfacing material for county road construction, and is laid cold for this purpose. While these are the only two commercial operations carried on with these materials, there are numerous and well distributed deposits of other basalts and rock asphalts in this county, most of which are very satisfactory for road construction. However, it is doubtful whether any of them will prove of commercial value due to the fact that they are not suitably located or the deposit is not of sufficient size to warrant development.

A deposit of asphalt limestone found on Turkey and Gato creeks, south of Cline Station is owned by the Uvalde Rock Asphalt Co., San Antonio, Texas; J. P. Smyth, President, Beaumont, Texas. Seven hundred and eighty-five thousand yards of this pavement have been used in Beaumont, Houston, San Antonio, Dallas, Austin, Taylor, and Bryan, Texas. There are very extensive deposits along Turkey and Gato creeks. A thickness of at least 25 feet of bituminous limestone is exposed and the entire thickness is in all probability considerably greater. A well on Gato Creek, 1½ miles south of the outcrop was reported to have contained asphalt rock from the surface down to its entire depth of 300 ft. Asphalt is also found to the west on James' Ranch one mile west of the Kinney-Uvalde County line.

The fresh rock is fairly uniformly impregnated with bitumen, the average of three analyses showing 12 per cent bitumen and 88 per cent calcium carbonate. The surface rock at the quarry site is weathered to such an extent that the bitumen has been removed from the upper several feet. There is a very irregular contact line separating the bituminous rock from the weathered surficial limestone. The limestone was originally a shell marl,

the pores and fossil shell moulds in which have been filled with asphalt. The rock is easily quarried. It contains in places rather irregular and large sized nodules of chert.

A water supply has been obtained by the construction of dams. It will be a comparatively easy matter to build railway spurs to any portion of the deposit. There is a very large supply of material available, which can be worked very economically by large scale operations; however, it would be advisable to test out the thickness of the asphalt rock in various places by drilling or sinking prospect pits, before any very large operations were contemplated, but in any event it is certain that the deposit is large in extent.

Within the last five years, the Uvalde Rock Asphalt Company has been treating its limestone rock asphalt by fluxing it with an asphaltic oil, which softens it to such an extent that it relieves the cracking experienced by the old method. The material is laid much like sheet asphalt pavement, with the exception that the binder course is omitted. The foundation is usually five or six inches of concrete which is allowed to set, and the wearing course consists of about two or two and one half inches of fluxed rock asphalt, laid hot. This is rolled with tandem roller and traffic is allowed on the streets in a few days.

As the rock asphalt, when it is mined, does not run uniform in its content of asphalt, it is necessary to combine definite proportions of the material from various parts of the deposit to obtain a uniform composition. The flux used is weighed so that each batch contains exactly the same amount. This is ground to small particles before placing in the mixer. The aggregate is then heated to approximately 270° F., by means of heated air so that the flame is unable to burn the asphalt.

Recently a method of laying this rock asphalt without the use of heat has been devised. This method is cheaper than the former method. It is recommended chiefly for surfacing of country roads which have already a compact surface. It has also been used, however, for the lighter traffic streets, in cities, with a concrete foundation. One notable instance of the use of this material laid cold on a good foundation is New Braunfels Avenue, San Antonio, Texas. This street was laid about two and

one half years ago with a surfacing of one and one-half inches of the Uvalde rock asphalt crushed to below one-half inch in size and laid cold. The foundation consisted of compacted macadam road. Today this street receives a great proportion of the heavy traffic due to the mobilization of the army at Fort Sam Houston and the Army Post.

To lay the surface of this material it is crushed to less than one-half inch maximum and placed upon the prepared foundation, whether it be concrete, compacted macadam, or gravel. The rock asphalt is then sprayed with some Mexican crude asphaletic oil which penetrates into the voids. The surface is then rolled rather lightly at first, and finally with a rather heavy roller. After this, a final dressing of what is known as "rock asphalt meal", a fine-ground rock asphalt, is spread over the surface and this again rolled, leaving the surface ready for traffic. Before the road is in its final condition, however, it is necessary that the surface be exposed to the heat of the sun to weld the various particles of the rock asphalt together into a solid, compact mass.

Thirty miles west of San Antonio, on the Southern Pacific Railroad, at Knippa, is located a deposit of trap rock (basalt). This deposit is owned by the Texas Trap Rock Company, San Antonio, Texas. The plant is situated upon the main line of the Southern Pacific Railroad with enough track to store thirty cars. The stone has been used by the Southern Pacific for ballast for about fifteen miles of their track with excellent results. The daily production with the present equipment is approximately seven hundred tons per day of two and one-half inch stones. The smaller sized material necessarily reduces this amount. The plant is equipped with a No. 7 Allis Chalmers gyratory crusher, and two No. 5 gyratory crushers with manganese steel crusher plates. A set of rolls produce stones below one and one-quarter inches in size. The crushed stone is then conveyed up to the screens which are twenty feet long and four feet in diameter producing six sizes of stone. The stone is stored in bins directly over the railroad tracks so that the stone is loaded directly. The quarry face is six hundred feet long and varies from sixty to eighty feet high. Numerous tests have been

made on this material by various laboratories, all of which show that this stone is undoubtedly the most satisfactory stone produced in the state for heavy traffic roads or streets. Tests made by the Road Materials Laboratory of the University of Texas indicate that the small sizes of this stone (below 1¼ inches) make a very satisfactory aggregate for concrete roads or streets.

A sample of this nephelite basalt has been tested as follows:

Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
3.15	196	0.39	1.8	22.2	17.5	15	Good	------

This specimen is a dense, gray black, porphyritic rock composed essentially of large crystals of olivine embedded in a fine grained ground mass of augite, nephilite, and magnetite. This is a hard rock, showing high resistance to wear, average toughness and good cementing value. It should make a very good road material.

Another deposit of trap rock asphalt is located one mile north of the San Antonio-Eagle Pass Highway, 8 miles south of the G. H. & S. A. Railroad, 8 miles west of the S. A. U. & G. Railroad, and 5 miles from the Uvalde Rock Asphalt spur leading from Cline. The owner is George E. Brashear, Uvalde County, Texas. The material comprises 150 acres in a hill 50 to 125 feet in height and has never been worked.

A deposit of basalt is found at Asphalt Mountain, southeast of Cline on the G. H. & S. A. Railroad and it is considered excellent road material.

Numerous deposits of nepheline-basalt are reported with rather poor shipping facilities on the G. H. & S. A. Railroad. They are as follows: (1) located in flat about six miles south of Knippa and two miles east of Frio River; (2) located at Taylor Hills, five miles southeast of the town of Uvalde; (3) at Blue Mountain, one mile north of Knippa; (4) located one mile east of Tom Nunn Ranch and five miles south of Nueces siding on the G. H. & S. A. Railroad; (5) at Tom Nunn Hill west of Nueces River, five miles south of G. H. & S. A. Railroad; (6) at Moore

Ranch (Black Waterhole) on the Frio River; (7) along the Blanco River south of G. H. & S. A. Railroad with shipping facilities at Yucca siding; (8) located on two knobs just south of Yucca siding on the G. H. & S. A. Railroad; (9) at Allen Mountain (Hill) Obi siding; (10) on Nueces Hill; (11) on two small knobs west of the Nueces River and east of Wagon Wheel Hill; (12) on Green Mountain twelve miles north of Uvalde; (13) on a knoll northeast of Big Mountain; (14) in a low area between Sulphur Mountain and Nueces Hill. Most of these basalts are dark, fine-grained and massive, the last three being plagioclase; and they make excellent road material.

There are also several deposits of phonolite reported from this county as follows: (1) located midway between Moore and Connor's ranches (two outcrops) and three small outcrops along Frio River, one and one-half miles south and southeast of Connor's Ranch; (2) on a small hill midway between Black and Big Mountains, three miles north of Ange siding; (3) on Rocky Hill, three miles southwest of Uvalde; (4) at Ange siding; (5) four miles north of Uvalde station; (6) at Inge Mountain, three miles south-southeast of Uvalde. These are good materials for road construction, but the shipping facilities are not satisfactory.

In the southwestern corner of the county, on the hill below Lewis ranch on the Frio River, is a deposit of gravel with flint pebbles averaging fifty feet in height, spreading out and covering the present stream, dividing south of the line of limestone cliffs of the Balcones escarpment. The shipping facilities are at Cline, Uvalde, Nueces, and Obi siding on the G. H. & S. A. Railroad.

Val Verde County

This county is well supplied with road materials satisfactory for the traffic needs of the county. The nature of the country precludes the possibility of any large agricultural development in the near future, except along the Devil's River and, with few exceptions, it is safe to say that most of the roads of the future in this county will be lightly traveled. This being the case, the roads can be surfaced with the natural materials. On the divides

where the surface material is the Eagle Ford formation, little other material is necessary. This compacts into a hard crust and resists wear to a considerable extent. In many of the draws good gravel can be found for the surfacing of the roads in the vicinity. This gravel is, as a general rule, satisfactory as a concrete aggregate, so that a ready material is available for the construction of concrete fords or bridges, should the latter be considered necessary.

Along the Devil's River Road, where the heaviest traffic to the north exists, materials are close at hand. Gravel is found along the bed and banks of this river and is very satisfactory for road construction. The tests on several gravels are included in this report. The surrounding rock is the Comanchean limestone, which the accompanying analysis shows to be equal to any limestone in the state for road construction.

The one heavy traffic road in the county is the Del Rio-Comstock Road, which will undoubtedly have to be surfaced with a road metal in the near future. Local materials can be used, for the most part, for this purpose. The presence of the railroad will permit the importation of materials, where the local materials are not found satisfactory.

The following are the results of tests made on representative materials found in this county:

MECHANICAL ANALYSIS

	No. 1	No. 2	No. 3
Material retained on the 2-inch sieve	9.8	8.8	6.6
Material retained on the 1-inch sieve	27.6	33.9	19.9
Material retained on the ½-inch sieve	42.1	58.8	48.7
Material retained on the ⅛-inch sieve	67.3	78.5	68.8
Material retained on the .033 inch sieve	83.0	83.3	70.0
Material retained on the .0116-inch sieve	88.2	89.1	74.2
Material retained on the .0058-inch sieve	89.2	90.8	77.0
Material retained on the .0029-inch sieve	89.7	91.9	78.4
Material passing the .0029-inch sieve	9.7	7.3	21.4
Total	99.4	99.2	99.8
Cementing value on:			
Material over ⅛ inch in size	------	------	------
Material under ⅛ inch in size	Poor	Poor	Fair
Material as received	Fair	Good	Excell.

No. 1. This sample of gravel was found ten miles south of Juno, Val Verde County, along the bank of the Devil's River, where Devil's River Road crosses the river. This is a well-graded gravel, composed of rounded pebbles of a hard limestone with sufficient clay to supply the necessary binder. This material is very satisfactory for road construction. Roads having considerable automobile traffic, should, however, have a bituminous topping.

No. 2. This sample of gravel was found in the bed of Devil's River at the crossing of the Del Rio-Comstock Road, Val Verde County. This is a wellgraded gravel composed of rounded pebbles of limestone and some flints. It should make a satisfactory road material. Stones over 2″ in size should be removed from gravel when road is being constructed.

No. 3. This gravel was found on the bank of Sycamore Creek, 12 miles southeast of Del Rio at the crossing of the Del Rio-Eagle Pass Road. This is a well-graded gravel composed of rounded pebbles of a hard limestone and a small amount of chert with considerable good binder. It should make a very good road material, but stones over 1½″ or 2″ in size should be removed before the gravel is compacted in the road.

Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
2.66	166	1.49	3.8	10.4	13.5	7	Fair	15,500

This sample of limestone was found on the road from Del Rio to Sonora, about 10 miles north of Val Verde County. This limestone is rather soft with low toughness but medium resistance to wear, fair cementing value, and medium resistance to compression. It is about an average of the better types of limestone in use for good road construction in Texas. It should be satisfactory for medium traffic roads, or in a concrete road under fairly heavy traffic.

Victoria County

Along the Guadalupe River in this county are found quantities of washed and screened sand and gravel. Samples on hand indicate that the sand is rather medium fine, clean, white, quartz sand. The gravel is washed and screened and it is composed of flint and quartz pebbles. The Guadalupe River Navigation Company is the owner of this material. This company operates a gravel plant at Victoria, Texas.

Two and one half miles from Victoria, and 500 yds. from the Southern Pacific Railroad is a gravel pit, which, however, has not been worked. The owner of the pit is John Koch, 307 N. De Leon St., Victoria, Texas.

Near Nursery, Texas, is a deposit of gravel belonging to John McCrabb (Callahan & Crawford pit). This material tested as follows:

MECHANICAL ANAYLSIS

	No. 1
Material retained on the 2-inch sieve	0
Material retained on the 1-inch sieve	9.58
Material retained on the ½-inch sieve	40.48
Material retained on the ¼-inch sieve	78 54
Material retained on the .033-inch sieve	87.72
Material retained on the .0116-inch sieve	95.25
Material retained on the .0058 inch sieve	97.68
Material retained on the .0029 inch sieve	98 91
Material passing the .0029-inch sieve	0 97
Total	99.88
Cementing value on:	
Material over ⅛ inch in size	Poor
Material under ⅛ inch in size	Very good
Material as received	Good

This test was made at the request of M. C. Crawford, Nursery, Texas. The results show that this material consists essentially of rounded fragments of flint and some quartz free from clay, and fairly well graded. As this sample contains no clay binder, it would be necessary to add a binding material to make the road compact. It should make a very good concrete aggregate or railroad ballast, being well graded.

Walker County

A deposit of rock consisting mostly of hard, glassy quartzite, has been reported from this county. It is located at Wynne's Quarry on the hill south of Midway Road, 9.1 miles from Huntsville on the I. & G. N. Railroad. The rock on the surface exposure averages 13 feet with a base not exposed in most places, although on the southwest it is underlain by soft, light-brown sands. The indurated sandstone is above. The rim rock is 110 feet above Nelson Creek. The rock is much cross-bedded. Next to the base is an indurated layer of coarse angular quartz grit, the larger

particles of which are about ¼ inch in size, with black chert a minor constitutent.

Gravel with much sand is found on the Huntsville branch of the I. & G. N. Railroad between Phelps and Huntsville, and on the summit of the grade on the I. & G. N. Railroad at mile post 78 in the southern part of the county.

A test has been made on gravel taken from Clark's Pit at Huntsville, Texas, resulting as follows:

MECHANICAL ANALYSIS

	No. 1
Material retained on the 2-inch sieve	0
Material retained on the 1-inch sieve	3.4
Material retained on the ½-inch sieve	44.8
Material retained on the ⅛-inch sieve	98.9
Material retained on the .033 inch sieve	----
Material retained on the .0116-inch sieve	------
Material retained on the .0058-inch sieve	------
Material retained on the .0029-inch sieve	100.0
Material passing the .0029-inch sieve	0.0

Washington County

Several deposits have been reported from this county, as follows: (1) from 10 to 20 feet of hard quartzitic sandstone on the B. F. Fayette Farm, 4½ miles northwest of Burton, on the H. & T. C. Railroad; (2) Several feet of sandstone found on the B. F. Elliot farm in a bluff on Kerr Creek, 4 miles northwest of Burton on the H. & T. C. Railroad; (3) 15 feet of interbedded hard and soft sandstone, 1 mile northwest of Gay Hill on the G. C. & S. F. Railroad; (4) 15 feet of sandstone at Ced Quarry two miles southeast of Sommerville and about ¼ mile west of the G. C. & S. F. Railroad; (5) 10 feet of interbedded soft and hard sandstone on Yequa Creek about ¼ mile south of the G. C. & S. F. Railroad.

A test on the sandstone at Graville Quarry has been made resulting as follows:

Sp. Gr.	Wt. per cu. ft. Solid	Water abs. lbs. per cu. ft.	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
	143	2.67	5	7.9	16.7	12	93	------

Webb County

The chief road material in this county is gravel which is found somewhat widely distributed in the creek beds and on the summits of many of the bluffs. This is a large county, but it is a cattle country and therefore a large mileage of highly improved roads is not necessary. The quartzitic sandstone just about disappears in this county and is only apparent in loose sand with a few scattered boulders of harder sandstone which is unsatisfactory for road construction. One deposit of the quartzitic sandstone is found southeast of Ochea one mile east of a low line of hills in two masses covering from thirty to forty square yards and fully twenty feet in height. The boulders are of all sizes, from a foot to those having a base of twenty square yards and ten to twelve feet thick. Many deposits of gravel have been reported from this county as follows: (1) three miles below the north line of Webb County and southeast of India Ranch, capping Webb Bluff on the Rio Grande; (2) at Guajelete Ranch on San Lorenzo Creek, in the northwestern part of the county; (3) capping butte, four miles north of Palafox near the Rio Grande; (4) five feet of gravel on the surface at prospect drill hole No. 2 by Cannel Coal Co., northeast of Carbon; (5) five feet of gravel on the surface about three miles southeast of Santa Tomas; (6) capping most of the hills along road from Richardson Ranch to San Lorenzo Creek; (7) flint gravel, which caps the divide between Chupadero and San Ambrosio Creeks on Eagle Pass-Laredo Road; (8) gravel and sand capping bluffs along the Rio Grande in the vicinity of Laredo; (9) gravel conglomerate, 12 miles north of Laredo on the I. & G. N. Railroad, owned by T. A. Coleman, of La Salle, Texas. This gravel conglomerate has been used for ballast by the I. & G. N. Railroad and it has also been used on the roads of Webb County.

Wharton County

In this county deposits of sand and gravel with pebbles of quartz, jasper, agate, limestone, flint, and granite have been found at Louise, and near Lizzie, both places being on the G. H. & S. A. Railroad.

Wichita County

The sand and gravel reported from this county is found near the Wichita and Red Rivers. One deposit, owned by Kemp Duncan, Wichita Falls, Texas, has no trackage from the pit, but the material has been used on short stretches of the Colorado and Gulf Highway.

The Wichita Sand & Gravel Company, Wichita Falls, Texas, owns a pit near Wichita Falls, on the Wichita River, and in 1916, about 3,500 tons were produced. This material consists of sand and gravel and is considered good road material, having been used on the roads around Wichita Falls.

Williamson County

Quite a number of samples have been collected from this county, but most of the stone is comparatively soft and unsuited for the ordinary water-bound macadam roads. A number of samples should prove satisfactory for bituminous roads under medium traffic or in concrete construction. There are numerous very satisfactory gravel deposits, many of which have been successfully used in constructing the present roads in this county. At Round Rock there is in operation a small rock crushing and screening plant, producing a comparatively soft limestone. This material is used as a concrete aggregate and for other purposes. Data from Mr. W. S. McGregor, Temple, Texas, follows:

Right at the depot at Circleville, Texas, there is an excellent deposit of road gravel but it is limited in quantity. One tract is owned by a negro and contains about 100,000 cu. yds. Another tract which has been opened and used on the local roads, (owner's name unknown) is just north of the depot and adjacent to the Katy track: the quantity here is only about 50,000 cu. yds. Two miles north of Circleville is located a gravel pit from which the Katy Railroad has taken gravel. The trackage has been removed, but there are only about 50,000 cu. yds. left. It is considered very good road material.

Fred Hoch of Taylor, Texas, owns a deposit of good road gravel near Circleville, Texas. The deposit contains approxi-

mately 50,000 yds. about one mile from the Katy Railroad tracks.

Tests on the limestones from this county have been made as follows:

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.60	162	1.66	3.0	13.2	14.3	7	11	13,725
2	----	---	----	3	13.5	13.8	7	15	17,050
3	2.60	162	2.95	3.1	13	13.3	7	29	15,050
4	2.60	162	2.14	3.4	11.7	13.8	6	38	13,400
5	2.50	156	3.72	4.2	9.5	11.1	4	44	8,950
6	2.55	159	1 82	6.2	6.5	13.9	4	Fair	11,725
7	2.50	156	3.74	not made	not made	11.1	5	Fair	15,300
8	2.30	143	7.14	13.5	3.0	0	2	Good	3,200
9	2.50	156	6.36	5.8	6.9	6.9	4	Good	9,520
10	2 55	159	3.80	5.4	7.4	11.2	4	Fair	12,950
11	2.45	153	5.04	5.6	7.2	7.8	4	30	9,050
12	2.40	150	5.03	7.5	5.3	3.7	3	9	8,140
13	2.60	162	2.70	4.3	9.3	15.2	5	19	13,400
14	2.50	162	2.64	4.4	9.1	15.2	5	29	11,550
15	2.40	150	6.78	5.5	7.3	7.5	2	47	6,190
16	2.50	156	1.78	4.3	9.2	9.5	4	14	11,250
17	2.25	142	6 16	29.7	1.3	0	2	17	4,025

Test No. 1. Limestone found along Lake Brushy Creek, about 200 yards above the I. & G. N. bridge. The test shows that this is a hard rock, with medium resistance to wear, low toughness, fair cementing value and also fair resistance to compression. It should make a satisfactory material for bituminous macadam roads.

Test No. 2. Limestone found near the I. & G. N. main line, about 3 miles southwest of Round Rock. The test shows that the rock has medium hardness, and resistance to wear, low toughness, fair cementing value and fairly high resistance to compression. It should make a very satisfactory material for bituminous road construction or for medium traffic plain macadam roads.

Test No. 3. Limestone found about 1¼ mile south of Round Rock on the I. & G. N. Railroad main line and on the McNeill wagon road. The test shows that this rock is rather low in hardness, with medium resistance to wear, low toughness, good cementing value, and fairly high resistance to compression. The material should be satisfactory for medium traffic bituminous construction or light traffic water bound macadam road.

Test No. 4. Limestone found near Round Rock, about ½ mile south and east from I. & G. N. Railroad, ¾ mile southeast of Round Rock. This is a rather soft rock, with medium resistance to wear, low toughness, good cementing value and fair resistance to com-

pression. It should prove satisfactory for road construction under medium traffic. Test made at the request of G. A. Burkman.

Test No. 5. This limestone was tested at the crusher plant on the I. & G. N. Railroad spur to Georgetown, owned by B. C. Richards, Round Rock, Texas. This is a soft rock, with low toughness, medium resistance to wear, and low resistance to compression. It is not recommended except for light traffic.

Test No. 6. This limestone was found 1½ miles west of Cedar Park on the H. & T. C. Railroad. It is a soft rock, having low resistance to wear and toughness, fair cementing value and fair resistance to compression. This rock is not recommended as a road building material, having no properties to recommend it for this purpose.

Test No. 7. Limestone found 2 miles east of Cedar Park on the A. & N. W. Railroad. This rock has low hardness and toughness, fair cementing value and rather high resistance to compression. It is not recommended as a material for road construction.

Test No. 8. Limestone found 1¼ miles from Liberty Hill and the H. & T. C. Railroad, the deposit being owned by Wm. Casheer. This rock has very low hardness, toughness and resistance to wear, low resistance to compression and good cementing value. It is not recommended for road construction, having none of the necessary properties.

Test No. 9. Limestone found on the H. & T .C. Railroad and northeast of Cedar Park on the property of E. Cluck. This is a soft rock, having low resistance to wear, and toughness, good cementing value and low resistance to compression. It is not recommended as a material for road construction.

Test No. 10. Limestone found on the Walsh Estate, ¾ mile northeast of Cedar Park, ¼ mile north of A. & N. W. Railroad. This is a soft rock, having low toughness, and resistance to wear, fair cementing value and fair resistance to compression. It is not recommended as a road building material, being too soft for this purpose.

Test No. 11. Limestone found 1½ miles north of Round Rock, on Brushy Creek, along the I. & G. N. Railroad. This is a soft rock, with low toughness, medium resistance to wear, good cementing value, and low resistance to compression. It is not recommended as a road building material nor as a railroad ballast.

Test No. 12. Limestone found about 1½ miles east of Round Rock and 300 yards west of the I. & G. N. main line near Fouse's switch on the Merrill land. This is a soft rock, with low resistance to wear and toughness, poor cementing value and low resistance to compression. It is not recommended as a road-building material.

Test No. 13. Limestone found about 2 miles east of Round Rock, on the I. & G. N. main line. This rock has medium hardness,

and resistance to compression. It should prove satisfactory under medium traffic in bituminous construction or light traffic in water bound macadam roads. It is also a satisfactory railroad ballast.

Test No. 14. This material was found about 1½ miles east of Round Rock, on Lake Brushy Creek, and about 300 yards southeast of the water tank on the I. & G. N. Railroad main line. Lower stratum. This rock has medium hardness, and resistance to wear, low toughness, good cementing value, and fair resistance to compression. It is recommended for bituminous construction only under medium traffic. It is a fair railroad ballast.

Test No. 15. This material was found about 1½ miles east of Round Rock on Lake Brushy Creek, about 300 yards southeast of the water-tank on the I. & G. N. Railroad main line. This is a soft rock, with low resistance to wear, very low toughness, good cementing value and low resistance to compression. It is not recommended as a road building material.

Test No. 16. Limestone found at the I. & G. N. Railroad quarry on the right of way, about 1 mile north of McNeill, Williamson County. This rock is low in hardness and toughness with medium resistance to wear and fair cementing value. It has also fair resistance to compression. This material is only recommended for light traffic in water bound macadam construction or under medium traffic with a bituminous binder. It should make a fair railroad ballast.

Test No. 17. This limestone was found ¼ mile from Round Rock and the Georgetown spur. It is a very soft rock, with very low toughness and resistance to wear and low resistance to compression. It is not recommended as a road building material.

Three tests have been made of gravel from this county as follows:

MECHANICAL ANALYSIS

	No. 1	No. 2	No. 3
Material retained on the 2-inch sieve	0	0	11.35
Material retained on the 1-inch sieve	11.96	18.05	32.80
Material retained on the ½-inch sieve	29.82	46.92	60.81
Material retained on the ⅛ inch sieve	52.78	78.27	85.43
Material retained on the .033-inch sieve	61.77	85.63	92.32
Material retained on the .0016-inch sieve	64.94	88.69	95.56
Material retained on the .0058 inch sieve	66.04	90.17	96.14
Material retained on the .0029-inch sieve	66.33	90.72	96.23
Material passing the .0029-inch sieve	34.29	8.62	3.49
Total	100.62	99.34	99.72
Cementing value on:			
Material over ⅛ inch in size	Excell.	Good	Good
Material under ⅛ inch in size	Excell.	Excell.	Excell.
Material as received	Excell.	Good	Good

No. 1. This gravel is composed of limestone fragments with a large amount of clay and fine calcareous material. It contains too much fine material to be recommended for gravel road construction, but it should make a very good binder for foundation of larger material. This gravel was found about 200 yards east of the I. & G. N. Railroad track and south of Round Rock near the city limits.

No. 2. This gravel was found on Lake Brushy Creek, just below the I. & G. N. Railroad bridge. It consists of more or less rounded fragments of limestone. It should prove satisfactory as a gravel road construction.

No. 3. This gravel was found in the W. J. Fouse pit, about 1½ miles east of Round Rock on the I. & G. N. Railroad switch on Brushy Creek. It is composed of rounded fragments of hard limestone with little fine material. It is satisfactory for road construction, but it will require considerable traffic to get it compacted. If screened and remixed properly, it should make a very good concrete aggregate. It is now one part sand to four parts coarse aggregate.

Wilson County

The San Antonio Sand Company, Mrs. P. W. Casseano, owner, San Antonio, Texas, operates a pit of concrete sand, 1½ mi. north of Calaveras on a spur of the S. A. & A. P. Railroad. During 1916, there were produced about 54,000 tons of sand and the present output is 350 tons per day.

Tests have been made and a sample of the sand sent to the laboratory for its mortar making qualities compared with Standard Ottawa sand. The results follow:

1:3 TENSILE BRIQUETTES (Lbs. per sq. in.)

San Antonio Sand		Ottowa Sand	
7 day test	28 day test	7 day test	28 day test
300	402	278	372

1:3 COMPRESSION CUBES (Lbs. per sq. in.)

San Antonio Sand		Ottowa Sand	
7 day test	28 day test	7 day test	28 day test
2,025	3,175	1,975	3,187

Therefore, both the 7-day and 28-day tensile briquettes made with San Antonio sand have 108% of the strength of Ottowa sand briquettes. The 7-day compression cubes made with San Antonio sand have 102% of the strength of the Ottowa sand briquettes and the 28-day cubes have 100% of the strength of the Ottowa sand.

The Wagner Sand Company of San Antonio also operates a sand pit in this county on the S. A. & A. P. Railroad. Tests made on the sand resulted as follows.

Weight per cubic foot, dry and loose	91¼	lbs.
Weight per cubic foot, dry and shaken	100	lbs.
Voids in loose sand	44	per cent.
Voids in packed sand	39	per cent.
Specific gravity	2.64	

The sand is composed of rather fine grains of quartz, free from clay or silt.

1:3 TENSILE BRIQUETTES (Lbs. per sq. in.)

Wagner Sand		Ottowa Sand	
7 day test	28 day test	7 day test	28 day test
233	308	293	356

1:3 COMPRESSION CUBES (Lbs. per sq. in.)

Wagner Sand		Ottowa Sand	
7 day test	28 day test	7 day test	28 day test
-----	2,280	-----	2,710

Therefore the 7-day tensile strength briquettes made with Wagner sand have 80% and the 28-day briquettes have 86% of the strength of the Ottowa sand briquettes.

The 28-day compression cubes made with Wagner sand have 84% of the strength of Ottawa sand cubes. The mechanical analysis of this sand follows:

MECHANICAL ANALYSIS

	No. 1
Material retained on the 2-inch sieve	----
Material retained on the 1-inch sieve	----
Material retained on the ½-inch sieve	----
Material retained on the ⅛-inch sieve	----
Material retained on the .093-inch sieve	5.2
Material retained on the .011C-inch sieve	57.4
Material retained on the .0058-inch sieve	95.8
Material retained on the .0029-inch sieve	98 5
Material passing the .0029 inch sieve	.9
Total	99.4

Wise County

Two miles south of Alvord, on the Ft. Worth & Denver City Railroad, there is a gravel and sand pit, owned by Oran Speer, Alvord, Texas. The production varies from 40 to 50 tons per day, and a switch from the railroad to the pit gives good shipping facilities. This material has never been used for road construction.

A limestone quarry is located 3 mi. north of Bridgeport and 8 miles west of Alvord on a spur of the Ft. Worth & Denver Railroad, from Alvord on the Margaret Swift Survey. A. B. Conley, Lubbock, Texas, is the owner. During 1914 about 100,000 tons were produced, but the equipment has all been removed, and the quarry shut down. However, a quarry face of 25 feet exists, so that it would be an easy matter to start operations. There is a spur of the Fort Worth & Denver City Railroad from Alvord, Texas, to the pit. A sample on hand indicates that this is a fairly hard limestone. It has been used on the Tarrant County roads to a great extent and also as ballast for the tracks of the Ft. Worth and Denver City Railroad.

The Chico Crushed Stone Company, Chico, Texas, A. S. Goetz, Agent, Ft. Worth, Texas, owns a limestone deposit at Morris Spur, on the Rock Island Railroad between Bridgeport and Chico, 47 mi. north of Fort Worth. The plant is equipped with one No. 7½ Gates gyratory crusher and one No. 5½ Gates and one No. 5½ Simms gyratory crusher, with a set of rolls for crushing small sizes. This equipment permits an output of 1,000

tons a day of crushed stone. The output for the preceding year was approximately 67,000 tons.

Two tests have been made on materials, the first sample being a light colored stone taken from the top of the quarry, and the second being a dark colored stone taken from down in the quarry. The results follow:

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.60	162	0.14	4.9	8.2	12.6	5	Good	15,400
2	2.70	168	0.36	5.7	7.0	15.8	5	Excell.	17,200

No. 1. The tests show this to be a rather soft rock with medium resistance to wear, low toughness and medium resistance to compression. It should prove fairly satisfactory in light traffic waterbound or medium traffic bituminous construction.

No. 2. The tests show this to be a medium hard rock, with low resistance to wear and toughness, excellent cementing value and fairly high resistance to compression. It should prove satisfactory in light traffic waterbound or medium traffic bituminous construction. It has a slight advantage over No. 1.

A sample of the crushed stone was tested in the laboratory for its usefulness as concrete aggregate and the results showed it to be quite satisfactory.

Wood County

The chief characteristics of the material in this county are that they are for the most part impregnated with iron ore. There is a number of ferruginous sandstones to be found, most of which are comparatively soft and will not stand up under traffic. The iron ore gravels have very high cementing value, which gives them a special value in road construction, as they are able to resist long periods of dry weather, and they pack well under traffic. Most of these gravels contain considerable fine pebbles of a disintegrated sandstone. Where these are found, the material is not considered first-class road material, as the soft stone will not resist wear. Some of the samples given

below, however, contain flint, quartz, and hard sandstone, which makes them very acceptable for road construction.

No.	Sp. Gr.	Wt. per cu. ft.	Water abs. lbs. per cu. ft	Per cent. of wear	French coef. of wear	Hardness	Toughness	Cementing Value	Compression lbs. per sq. in.
1	2.55	159	0.98	3.3	12.1	17.8	9	1	12,325
2	2.85	178	11.15	21.5	1.9	not	made	20	5,675
3	2.65	165	5.04	21.8	1.8	not	made	2)	------
4	2.70	168	5.54	35	1.1	not	made	45	2,175

No. 1. This sample of quartzite was found one mile south of Golden, Texas, at Negro Cemetery, on the property of Mr. John Reese, on the line of the M. K. & T. Railroad. The tests show that this rock has a high hardness, a medium resistance to wear, a somewhat low toughness and a very poor cementing value. It has a high resistance to compression. On account of its low cementing value, it should be used only in bituminous construction or it should make a good railroad ballast or concrete aggregate.

No. 2. This sample of ferruginous sandstone was found about 5 miles east of Mineola, about 200 yards north of Varner & Mineola Road on the property of Dr. Patton. The tests show that this material has a very low resistance to wear, fair cementing value, and low resistance to compression. It is not recommended as a road building material, for it is believed that it would wear to dust even on a very light traffic road in a short time.

No. 3. This sample of iron conglomerate was found about 5 ½ miles east of Mineola, about ¼ mile north of Mineola & Varner Road, at the tank. The property belongs to the Mineola Hunting and Fishing Club. This material is a conglomerate composed of flint and sandstone cemented together with a red oxide of iron. Its resistance to wear is very low and cementing value fairly good, but a material of this nature would not prove satisfactory for road building. It might be used for foundation course under light traffic.

No. 4. This sample of iron conglomerate was found on the side of the road on the Hawkin & Hainesville Road, opposite the oil well, about two miles southeast of Hainesville on county property. The tests show that this material is a conglomerate composed of small flint stones and sandstone cemented together with iron oxide. It has a very low resistance to wear and good cementing value. This material is not recommended as a road building material as it will wear to dust in a very short time. Even as a foundation course, it would be unsatisfactory except under light traffic.

The gravel in this county has been tested as follows:

MECHANICAL ANALYSIS

	No. 1	No. 2	No. 3
Material retained on the 2-inch sieve	0	3.3	6.9
Material retained on the 1-inch sieve	.9	17.4	21.3
Material retained on the ½ inch sieve	8.7	31.5	42.2
Material retained on the ⅛ inch sieve	57.2	67.7	70.9
Material retained on the .033-inch sieve	66.1	78.4	81.4
Material retained on the .0116-inch sieve	72.2	82.7	85.5
Material retained on the .0058 inch sieve	91.2	89.3	88.4
Material retained on the .0029-inch sieve	98.5	92.3	91.3
Material passing the .0029-inch sieve	----	7.6	9.6
Total	100.2	----	100.9
Cementing value on:			
Material over ⅛ inch in size	------	Good	Fair
Material under ⅛ inch in size	------	Excell.	Excell.
Material as received	------	Good	Good

No. 1. This sample of creek gravel was found in a creek about 4½ miles northeast of Mineola, about ½ mile west of Green Bridge. It was not found satisfactory as a concrete aggregate.

No. 2. This sample of iron gravel was found about 150 yards up the creek from wooden bridge on the Dallas and Shreveport road, about 5½ miles south of Mineola, on the property of Eliza Copeland. The tests show that this material is composed of fragments of flint and ferruginous sandstone with considerable sand and a small amount of clay. It should make a fairly satisfactory road building material. The exposure is not very heavy.

No. 3. This sample of iron gravel was found on the Riley Stewart estate, from Stewart Hill, about 300 yards west of Mineola and Tyler Road, and about 6½ miles south of Mineola. The tests show that this material consists of angular fragments of a ferruginous sandstone with considerable sand and clay. It should prove very satisfactory as a road building material. The exposure is very heavy.

The results of three more similar tests are given below:

MECHANICAL ANALYSIS

	No. 1	No. 2	No. 3
Material retained on the 2-inch sieve	7.8	19.5	9.56
Material retained on the 1-inch sieve	14.1	28.0	18.97
Material retained on the ½ inch sieve	20.4	37.3	28.56
Material retained on the ⅛-inch sieve	38.6	56.3	54.90
Material retained on the .033-inch sieve	44.2	60.6	63.46
Material retained on the .0116-inch sieve	46.1	62.0	64.53
Material retained on the .0058 inch sieve	51.9	70.5	69.50
Material retained on the .0029-inch sieve	57.0	74.4	75.57
Material passing the .0029 inch sieve	43.0	25.8	23.79
Total	100.0	100.2	100.36
Cementing value on:			
Material over ⅛ inch in size	Fair	Good	Very good
Material under ⅛ inch in size	Good	Very good	Excell.
Material as received	Good	Very good	Good

No. 1. This sample of iron-sand gravel was found on the Mineola Road, 1 mile west from red sand stone and about 7 miles east from Mineola, on county property. The tests show that this material is composed of fragments of a soft ferruginous sandstone with a large amount of fine sand and clay. It contains too much fine material and not enough large stones to be satisfactory as a road building material. Gravel should contain about 70 per cent of stones between ⅛″ and 2″ in size.

No. 2. This sample of iron-sand gravel was found on the Mineola and Varner Road, about 5¼ miles east of Mineola, on the property of Dr. Patton. The tests show that this gravel is composed of ferruginous sandstone with a large amount of fine sand and some clay. This material does not contain enough hard stones of a large size to be satisfactory as a road material. It is a good surfacing material.

No. 3. This sample of sandstone gravel was found on the property of Mr. Emory Palmer, 4½ miles east of Mineola. The tests were made upon the request of Geo. C. Reeves, Mineola, Texas. This gravel is composed of angular fragments of medium hard, ferruginous sandstone with a large amount of sand and clay. It is not recommended for general gravel road building, will do as a surfacing material or for general road construction if nothing else is available.

Zavalla County

Only three deposits of gravel are reported from this county. These are located as follows: (1) 60 ft. of gravel at the north end of the bluff on the Nueces River, just below McDaniel's Ranch in the north-central part of the county; (2) in patches from Batesville to the crossing of the Nueces River on the road to Carrizo Springs; (3) on the Nueces River, ½ mile below Pulliam Ranch.

APPENDIX

Physical Tests of Road Materials

J. P. Nash

The Testing of Road-Building Rock

The physical tests made on road-building rocks to determine their value are as follows: (1) hardness; (2) toughness; (3) resistance to wear; (4) cementing value; (5) specific gravity; (6) absorption; and (7) compression. The methods of making these tests in this laboratory are briefly described here.

The hardness test, which determines the resistance of the rock to disintergration from friction, is made in the Dorry hardness machine shown in Plate 1, which was first devised by the French School of Roads and Bridges in a modified form. The test is made on a core one inch in diameter and usually about 3″ in length, drilled from the rock, and placed in a spool-shaped receptacle, which holds it vertically against a revolving disc under standard pressure. The disc is fed continually from the hoppers with a standard crushed quartz between 30 and 40 mesh sieve. This crushed quartz acts as an abrasive agent. Two cores are run at the same time for 1,000 revolutions and the average of the two is taken in computing the coefficient of hardness. This is derived by weighing the specimen before and after the run, dividing the loss in weight by 3, and substracting the result from the arbitrary number 20. The degree of hardness varies, therefore, from 0 to 20, with the latter figure as a maximum. If it falls below 14, it is considered as soft; from 14 to 17, as medium hard; and above 17, as hard.

The toughness test is made on the rock to determine its resistance to impact. It is made in the machine shown in Plate II, devised by L. W. Page, Director of the Office of Public Roads at Washington. It is based on the pile driver principle. The specimen used is a rock cylinder 1 inch in diameter, and 1 inch in height, faced smooth on both bases. The tests consist in dropping

a two kilogram weight on the specimen through the medium of a steel cylinder whose curved lower surface remains in contact with the center of the rock specimen. The hammer is dropped from a height which is increased by increments of one centimeter (.4 inches) from one until the specimen breaks, which it usually does by splitting into two or three equal parts. The number of blows, which also represents the height of the last blow, measured in centimeters, is the numerical toughness. If the rock fails in less than 13 blows it is considered as having low toughness; from 13 to 19, as medium; and above 19, as high. A rock having a toughness of 9, however, is considered satisfactory and even one as low as 6 is often recommended. The average of two tests is taken.

The rock core used in both the hardness and toughness test is drilled from the rock by means of the diamond core drill shown on Plate III, cut and faced to the required size by means of the diamond saw and lap shown in Plate IV.

The abrasion test, also devised by the French School of Roads and Bridges, is made on the rock to determine its resistance to wear under traffic conditions. This test is made in the Standard Deval Abrasion machine shown in Plate V. By revolving the rock sample in one of the cast iron cylinders which rotates at an angle of 30 degrees to the horizontal, the rock is thrown from one end of the cylinder to the other and back, upon each revolution; ten thousand such revolutions constituting the test. The sample consists of rock broken by hand in sizes so that approximately 50 pieces will weigh 5,000 grams (11 pounds). This throwing of the rock from one end of the cylinder to the other causes the stones to wear upon themselves and to impact against the ends of the cylinder. The fine dust resulting from this wear is removed by screening and the stone reweighed, the loss being expressed in per cent, and also by the French coefficient of wear. This coefficient is obtained by dividing the per cent of wear into 40. The best wearing rocks have a per cent of wear 2 or coefficient of 20. If this coefficient of wear is below 8, it is considered as low; from 8 to 13, medium; from 14 to 20, high; and above 20, very high.

The cementation test is made on the rock to ascertain to what extent the fine material will bind into a hard, impervious crust

in a water-bound macadam. It is made by grinding 500 grams of the crushed rock below ¼" in size with 90 cu. cm. of water in a ball mill with two steel balls. The revolving of the mill causes the two balls to knead the rock into a kind of dough. The double ball mill is shown in Plate VI with the open mill on the right. After 5,000 revolutions in this mill, the rock dough is made into cylindrical briquettes 25 millimeters (1 inch) in diameter and 25 mm. (1 inch) in height, under a pressure of 132 kilograms per square centimeter (about 1,800 lbs. per square inch) in the hydraulic press shown in Plate VII.

These briquettes are allowed to remain in air 20 hours at room temperature, and 4 hours more at 100 deg. C. (212 deg. F.), after which they are cooled and tested in the Page Impact machine for cementation tests, shown in Plate VIII. This causes a 1 kilogram (2.2 lb) hammer to drop 1 centimeter (.4 inches) repeatedly until the specimen breaks. The number of blows required to break the specimen is recorded automatically on a sheet of indicator paper so that a permanent record is obtained. The cementing value is considered as being low if below 10 blows; between 10 and 25, as fair; between 25 and 75, good; 75 to 100, very good; and above this, as excellent.

The specific gravity of all rock samples is obtained by weighing the dried specimen in air and then in water, setting the weights on the balance to approximate the weight in water, before immersion. Ordinarily the specimen weighs about 20 grams in air.

The absorption is derived by allowing the rock to remain in water for 96 hours and is reported in pounds of water absorbed per cubic foot of solid rock.

As most crushed stone is bought by the ton, it is necessary to know the weight of a cubic foot of the material. The weight of a cubic foot of solid rock is obtained by multiplying the weight of a cubic foot of water, or 62.4 pounds, by the specific gravity. Knowing the voids in the crushed stone, its weight per cubic foot can be calculated by substracting from the weight of a cubic foot of the solid rock, the weight of rock represented by the voids. This may be reversed and the voids found, if the weight of loose stone is known.

The compression test is made on the rock to determine the weight it will carry without rupture, but more especially as an index to its general qualities. A road building rock is not required to have such resistance to compression to any marked degree, but in testing material for railroad ballast or building stone, the determination of compression strength is demanded. It is also a good test for concrete aggregate, stone block or brick paving material. A two-inch cube bedded in plaster of Paris is used as the specimen to be tested. It is broken in the 100,000 pounds testing machine shown in Plate IX. To be recommended for a railroad ballast, it is necesary that the rock should have a compressive strength greater than 10,000 lbs. per sq. inch, besides howing up well in the other tests. A rock has a fair resistance to compression if it will break at between 10.000 and 15,000 pounds pressure per square inch; good if between 15,000 and 18,000 pounds per square inch; very good from 18,000 to 20,000 pounds; and excellent if it resists compression above 20,000 pounds per square inch.

The Relation of the Tests to One Another

In a paper presented before the 1913 convention of the American Society for Testing Materials, L. W. Page showed the relation of various road material tests to one another. The relation between the hardness and toughness tests was brought out in a curve which showed that for high toughness, the hardness is invariably high, but when the toughness is low, the hardness may be either high or low. A somewhat similar relation was established between the toughness and the abrasion tests. It was shown that where a high toughness exists, a high coefficient of wear is found. As in the case of the hardness test, a low toughness rock may have either a high or low coefficient of wear. Between the abrasion and hardness tests no relation could be definitely established.

From the results of about 125 of these tests on rock, curves have been drawn illustrating the relation between compressive strength and toughness. The curves indicate that for high toughness the compressive strength is invariably high.

As in the cases noted above, the compression may be high or low, when the toughness is low. Thus, if a hard rock with high resistance to wear and compressive strength is desired, it would only be necessary to require that it show high toughness; but with rocks low in toughness, all degrees of hardness, resistance to wear, and compressive strength could be expected, depending in a great measure upon the type of rock.

Recommendations of Rocks

Recommendations are based on the results of the tests and to some extent upon the variety of the rock itself, the type of road to be constructed and the amount of traffic it has to support.

A heavy traffic road of water-bound construction demands that the stone be hard and tough, with a high resistance to wear, and that it have a good cementing value. It is possible that this same material might be too hard for a lighter-traveled road, as the amount of material worn off by traffic would be insufficient to supply the powder needed as a binder to replace that carried away by wind and water, and the road would soon ravel. A light traffic road requires a softer rock. Material suitable for light traffic roads is abundant in Texas, and it needs little persuasion to have road-builders use it, no matter what the class of traffic might be. The average stone found in Texas could be classed as suitable for medium traffic roads.

It is necessary that there be an understanding of what is meant by heavy, medium, and light traffic on country roads. In the discussion and tables, the following classification will be used:

A heavy traffic road is one upon which considerable heavy hauling is done, such as a main highway leading into a town or city; or a street in the suburbs of a town or city, not a business street. Ordinarily such a traffic will also be quite dense.

A medium traffic road designates one having considerable traffic of a light nature mingled with some heavy loaded travel, such as would be found on an ordinary country highway or main road, a considerable distance from town.

A light traffic highway is one having nothing but lightly loaded vehicles traveling upon it, such as carriages or light wagons; as, for instance, a park or private road.

Since modern traffic is approximately 90 per cent motor-driven vehicles, the plain macadam road of a decade ago is being rapidly replaced by those treated with a foreign binder. The properties of road materials are somewhat different according to the type of construction used. From the nature of the binder, a bituminous road is resilient in itself and therefore the rock need not be one of high toughness nor cementing value. The resistance to wear will be the best index of its quality when used in this type of road.

As a general rule the rocks recommended for a certain class of traffic in plain macadam construction may be used with satisfaction on roads having a heavier class of traffic, if used in bituminous construction. That is, a limestone which is recommended for medium traffic in water-bound construction, would be satisfactory for heavy traffic in a bituminous road, provided the toughness was as high as 8, or over.

The Testing of Road Gravels

It is presumed that the sample of gravel to be tested is a good average of the material to be used. The material for the sample should be taken from a number of places in the pit, be mixed all together, and about 25 pounds of this taken to be used as the test sample.

The testing of gravels is divided into three parts: (1) the grading test; (2) the cementation test; (3) the identification of the material. Besides these, the voids determination is sometimes made.

The Grading Test

In order to reduce the sample to a size small enough to be sieved, it is well mixed and quartered, to get about 2,000 grams for the cementation test and also for a permanent sample to be filed with the recommendations.

Before the sizing test or mechanical analysis is made, the gravel is washed in order to remove the clay. To do this the gravel, which has been dried at 100 deg. C. and then weighed, is agitated in a shallow pan containing water, for not less than 15

seconds, and allowed to settle for not less than 15 seconds more, when the water with the clay held in suspension is poured off. This is repeated until the water remains comparatively clear after stirring. The washed gravel is dried and weighed again, so that the difference in weight is the clay and very fine silt. This very fine material will all pass the No. 200 sieve, which means that the particles are less than 1-350 of an inch in diameter, and represent the binder in the gravel.

The washed material is then run through both the stone and sand sieves. The stone screens are seven in number, made of plates with round openings corresponding to the following diameters: 2-inch, 1½-inch, 1¼-inch, 1-inch, ¾-inch, ½-inch and ¼-inch.

The material passing the ¼ inch sieve is classed as sand and is run through the wire sand sieves of the Tyler system. from No. 10 to No. 200, including the following sieves: No. 10, No. 20, No. 28, No. 35, No. 48, No. 65, No. 100, and No. 200. Such material as passes the No. 200 sieve is a very fine sand, which failed to go off in the washing test. It is always a very small amount, seldom more than 1 per cent; and this is classed with the clay.

The machine shown in Plate X is the mechanical sieving device, used in making the mechanical analysis. The sieves are meshed as shown and the sample run through all of them at one shaking by the vibrator during the space of 20 mintes.

The Cementation Test

The cementation test is made on gravels by the same methods as in a rock sample, except that three determinations are made on one gravel sample: (1) on the material as it comes from the pit; (2) on the stones failing to pass the ¼ inch sieve; (3) on the sand and clay passing the ¼ inch sieve.

With a gravel, as with rock, the dust worn off from the stones often supplies a binder, especially in a limestone gravel. To ascertain the quality of this binder, a cementation test is made on the larger fragments of the gravel. By a cementing value determination on the material under ¼-inch in size, the relative binding properties of the clay or very fine material are brought

out, while a determination on the sample as run in the pit gives an index of what may be expected of the road after it has begun to wear. This latter value will fall between the first two.

It is essential that the material under ¼-inch should show a high cementing value, as this is the material which holds the larger stones together and forms the impervious crust essential to a permanent road. The cementing value on this should range over 100. With gravel a different classification is used than is the case with stone. Below 100 is considered as poor, from 100 to 250 is fair, from 250 to 500 is good, and above 500 is excellent.

Identification of Material

An examination of the material is made in the laboratory to ascertain the composition of the gravel, the hardness and kind o frock from which it is derived, and also the nature of the fine material, all of which aids in the judgment of the value of the material for road-building.

Recommendations of Gravel

In judging gravel from the results of the tests, due consideration is given to the fact that it is very difficult to get a small sample which would exactly represent the pit, and figures are considered only in a relative sense.

In recommending a gravel as being satisfactory, it is considered that the stones themselves shall be hard and fairly well graded in size, with enough sand—and only enough—to fill the voids. Experience seems to indicate that this amount should be about 30 per cent of the sample. In order to carry this over the dry spells, it is necessary that about one-third of the sand be replaced by clay or 10 per cent of the entire sample. This is not enough to become muddy in wet weather, and just enough to keep the road well bonded, over an ordinary dry spell.

The kind of material making up the gravel has considerable influence upon the clay question. The above discussion is primarily for quartz, flint or granite gravel, but as a good proportion of Texas gravel is of limestone origin, this must be con-

sidered also. The stones themselves will supply the bond so that little fine material is necessary and, in fact, very little is found in this type of material. The fine material is usually of a calcareous nature and proves a satisfactory binder. Furthermore, as limestone pebbles themselves are subject to considerable wear, the gravel is continually supplying fine material, so that the initial amount need not be more than 7 per cent of the sample. Some limestone gravels are too soft for road construction and should not be used, except under very light traffic or as a foundation course with a wearing surface of better material. From the nature of the mode of formation of gravels, they should have a high resistance to wear, but if the gravel is deposited near the source of the rock from which it is derived, it need not be hard, as it has little chance to wear before being deposited.

In considering further the grading of a road gravel, it would be incorrect to say that only those gravels having 30 per cent sand are satisfactory. These, however, have given the best service. Good roads are in service where a much higher sand and clay content than this has been used, but roads built of such gravel require more maintenance and do not last as long. Gravels are tested that have over 75 per cent of their material below the ¼ inch sieve, but they are really sand, and can only be recommended as a sand-clay construction material.

Gravels lacking clay, with the exception of limestone gravels, give fairly good results for the first year, but after that they become very dusty unless there is considerable underground water present.

The Testing of Other Materials.

This includes granite and wood blocks, brick, concrete, and bituminous materials. Tests of these are valuable in ascertaining for the purchaser just what grade of material he is getting. They enable him to buy his road on definite specifications, with the assurance that they will be complied with.

Granite Blocks.

Granite blocks are tested for their properties as to hardness, toughness, and resistance to wear in the same manner as rocks for macadam roads. A compression test is also made on a 2-inch cube cut from the block. The greatest importance is given the toughness test, as a tough granite will be hard and have a high resistance to wear. In fact, this is the only test demanded by many specifications, while others include the compression test of 18,000 or 20,000 pounds per square inch. The American Society of Municipal Improvement recommended a toughness of 9 as a minimum for granite, but this is a rather low figure. The stone itself should be even-grained, without disintegration, or an overabundance of mica or feldspar, and the blocks should run in uniform size.

Very few granite block pavements have been laid in Texas, due probably to the fact that the traffic conditions did not warrant the cost. Excellent granite can be had in Texas for this purpose and a larger field should be developed for its use.

Wood Blocks.

Wood blocks are usually specified as to size, variety of wood and kind and amount of filler used, and are tested for these properties. The common practice is to use a filler of creosote oil of a specific gravity of about 1.10 at the rate of about 16 to 20 pounds per cubic foot, varying according to the variety of wood and the traffic. The variety of wood is usually limited to yellow pine, Norway pine, Douglas fir, and tamarack, of even growth and free from knotholes.

The only test considered necessary is to test the filler to see that it passes specifications, which are usually those of the Association of Standardization of Paving Materials. Absorption of the block is sometimes determined, but it varies to such an extent that it is of little value. Wood block pavements are confined to heavy traffic streets and have not been used in this State in road work, on account of their high cost.

Paving Brick.

Paving bricks have taken a big stride into public favor in the last few years, from many causes; one of which is the uniformly good grade of bricks that the manufacturers are turning out.

In testing brick, the sample should be a representative one and not less than 10 brick for each 10,000 to be used should be tested, in order to secure a good average of the shipment. The sample, however, should not include any brick that would be culled out upon visual inspection.

The tests on brick include hardness and toughness tests, made on a core drilled from the brick, as is done in the rock test. The cross-bending test is also made as an index to the quality of the brick. It is made by applying a load by means of a knife edge in the center of the brick which rests on two other knife edges, 7 inches apart. The modulus of rupture is calculated from the breaking load. A compression test is also made on a 2-inch cube cut from two blocks. Besides these, the absorption and specific gravity tests are made.

These tests are of little value themselves, but on account of the correlation of data of a considerable number of blocks known to be satisfactory, a good estimate of their value can be given.

The most meritorious test, however, on paving brick is the rattler test, which is described in the 1913 Proceedings of the American Society for Testing Materials. It consists of revolving 10 blocks in a cast-iron barrel, 28½ inches in diameter and 20 inches long, inside. The machine is also charged with an abrasive agent, consisting of 10 cast-iron spheres, 3¾ inches in diameter, and 250 smaller ones, 1 ⅞-inch in diameter. It is revolved for 1,800 revolutions at 30 r., p. m. Some authorities, however, prefer that the shot be omitted in making the test.

The loss in weight is reported in per cent, and should not run above 24, for heavy traffic street work.

The manufacture of paving brick in the State is very limited; in fact, only one company now in operation is known to the Bureau, this being located at Thurber, Erath County. The tests on some brick from this place show them to be of excellent quality.

Concrete Materials.

The concrete pavement has of late taken a permanent place among the modern highways, and when well constructed with good materials, fulfills expectation.

The testing of concrete for road work is limited to ascertaining the properties of the aggregate used. The cement is tested according to the methods of the American Society of Testing Materials and is required to pass these specifications.

The sand used in the concrete is made into briquettes using one part cement and three parts of the sand by weight. Coincident with these 1:3 tensile briquettes of standard Ottawa sand are made; and at the same time, 2-inch cubes are made of the same mix. These specimens are required to show at least the strength in tension and compression of the standard Ottawa sand specimens. The grading and composition of the sand is ascertained. Quartz or flint sands are the best, but a hard limestone is quite satisfactory. If the sieving test shows more than three per cent silt below the No. 200 sieve it is questionable whether the sand should be used without being washed.

The coarse aggregate should be a hard, durable material that will resist the wear, and be well graded between ¾″ and 2 or 2½ inches. An essential feature of the coarse aggregate is that it be uniform in character, whether it be gravel or crushed stone. This insures uniformity of wear on the concrete road surface and is of as much importance as the hardness of the aggregate. Gravels uniform in character—limestone, trap rock or granite—are all good aggregates. The stone itself should have a coefficient of wear of at least 8, although under medium traffic a coefficient of wear of as low as 7 might be successfully used. Like all concrete aggregates, the coarse aggregate should be practically free their grading and gravels are usually washed to determine the amount of silt or clay. Compression cylinders 6 inches in diameter and 12 inches high, using definite proportions of aggregates and a standard cement, are tested usually after curing 28 days. This compression test is made as a check test as the time necessary to make it prevents an early result. A number of tests have been devised to test concrete for its wear resisting

properties, by subjecting the surface to wear with some abrasive agent.

Bituminous Materials.

This subject is such a broad one that it will not be considered in this discussion, further than to emphasize the necessity of buying these materials on specifications, and of seeing that these are complied with. For each type of bituminous construction, a different oil is necessary, the requirements being modified by the method of application and the results desired. The tests demanded may all be included under the head of physical testing, although most of them are made on such equipment as is found in a chemical laboratory.

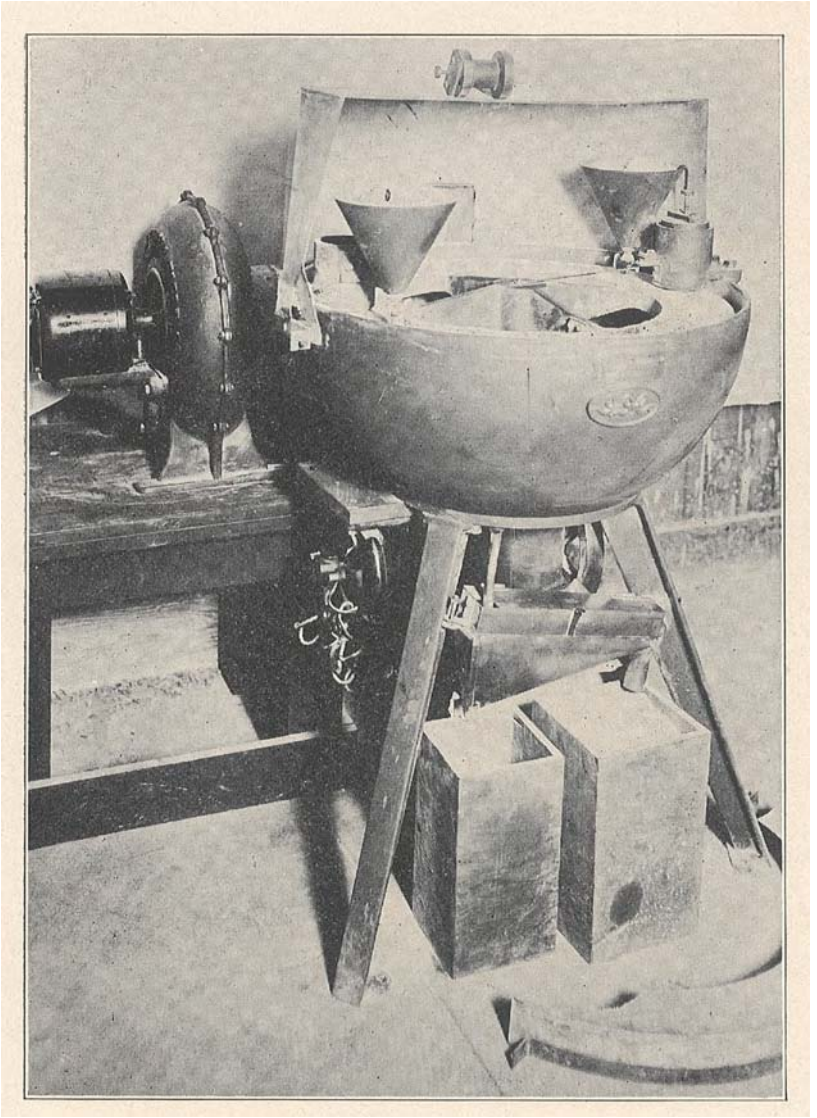

Plate 1. Dorry Hardness Machine.

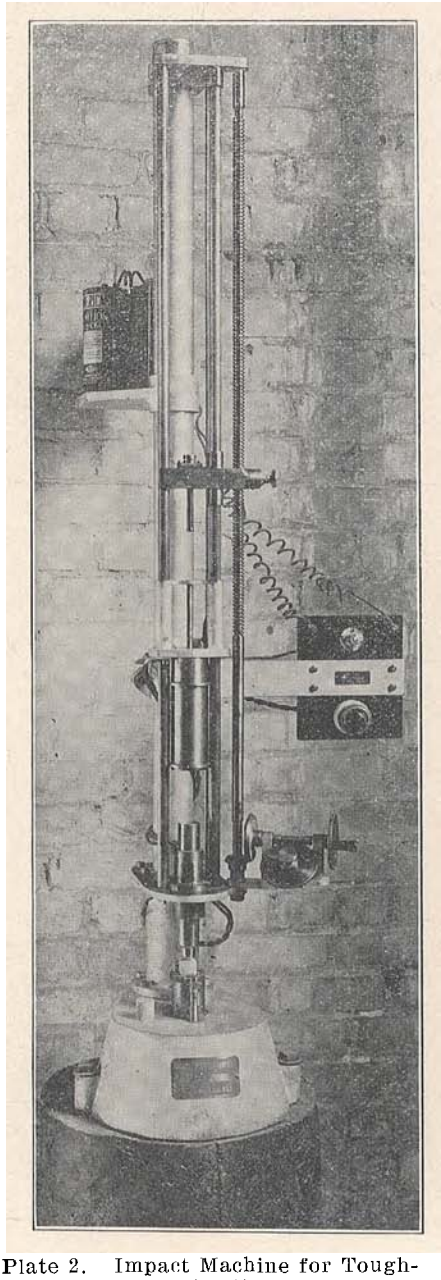

Plate 2. Impact Machine for Toughness Testing.

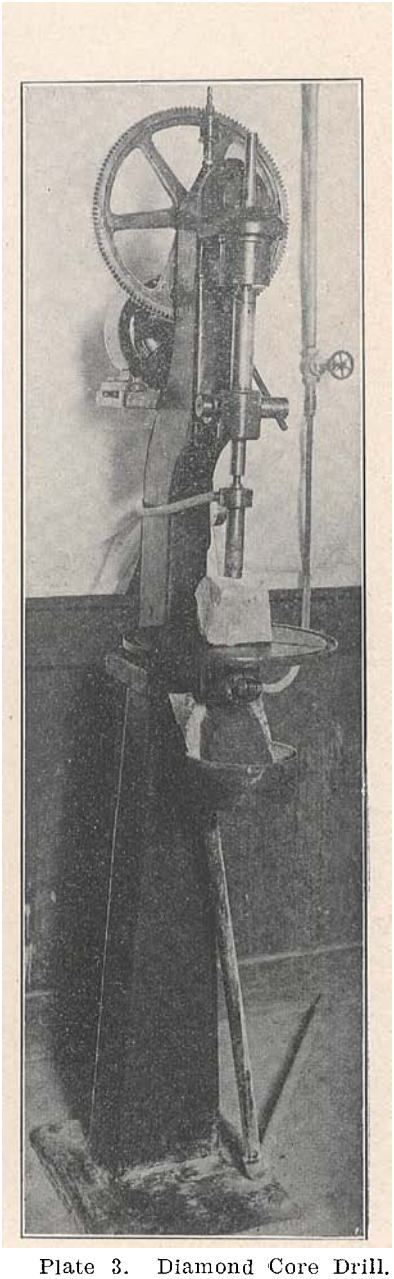

Plate 3. Diamond Core Drill.

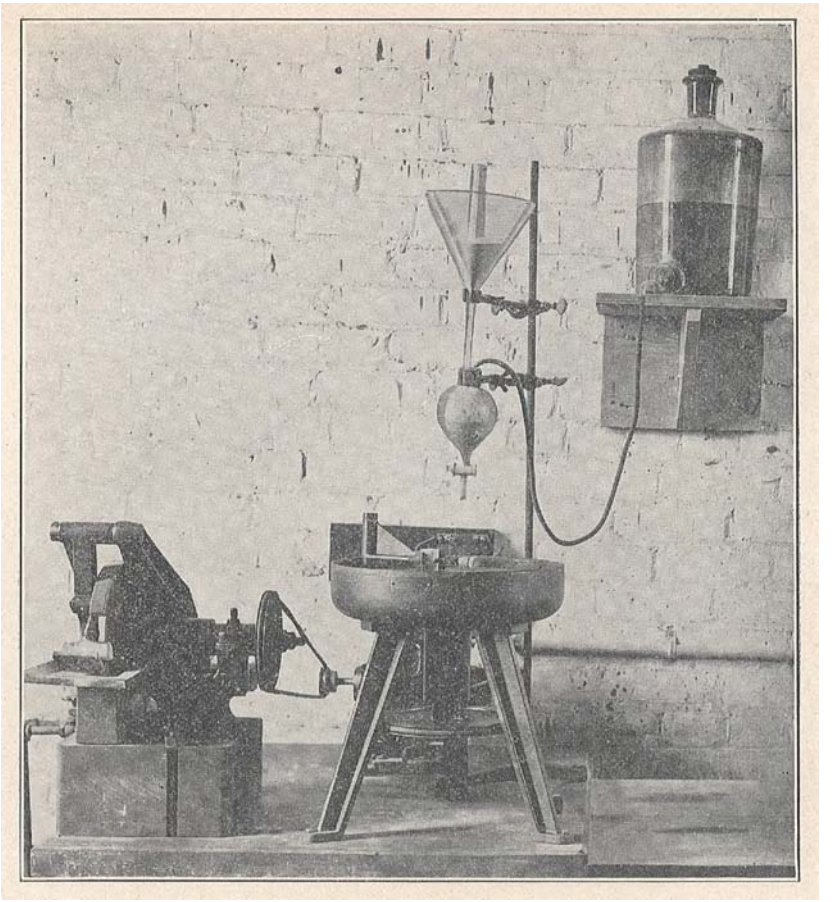

Plate 4 Diamond Saw and Lap Grinder.

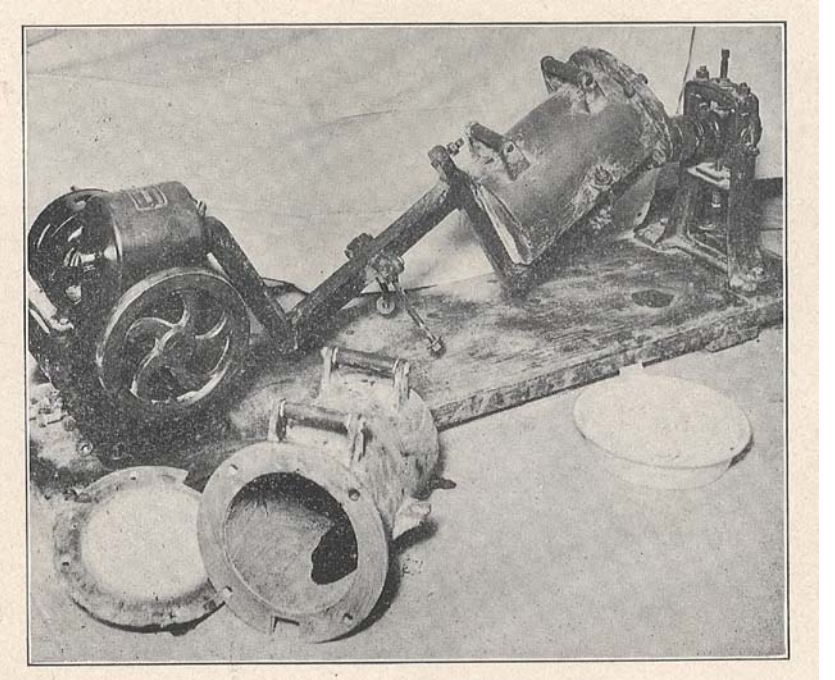

Plate 5. Duval Abrasion Machine.

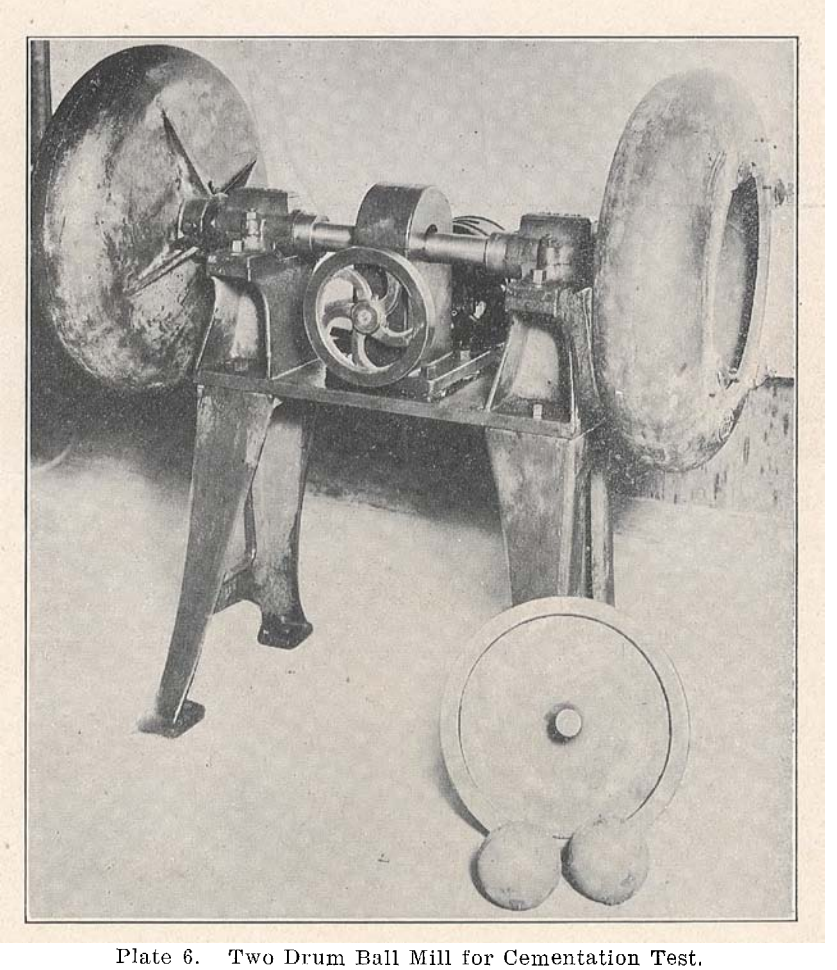

Plate 6. Two Drum Ball Mill for Cementation Test.

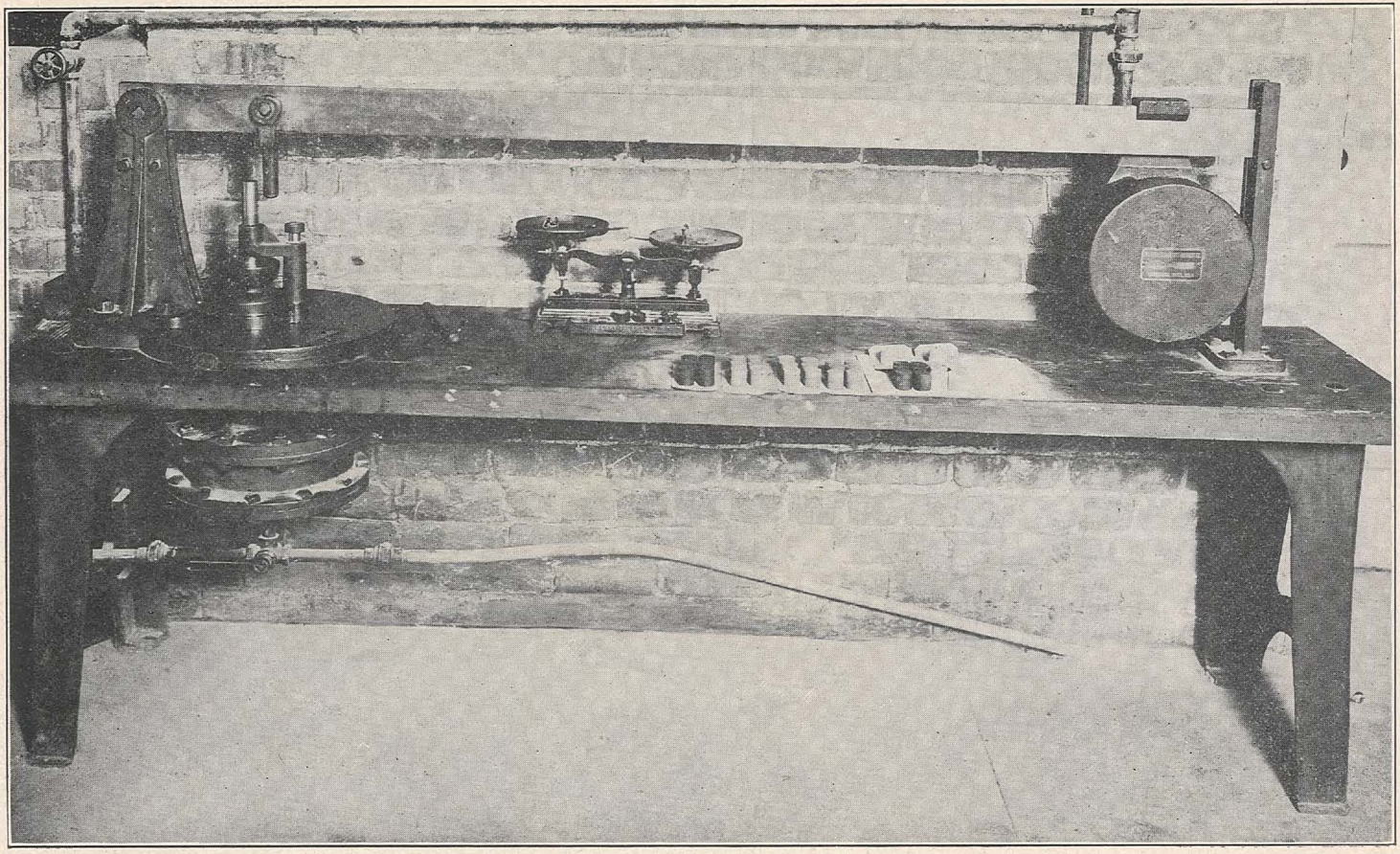

Plate 7. Hydraulic Press for Forming Cementation Briquettes.

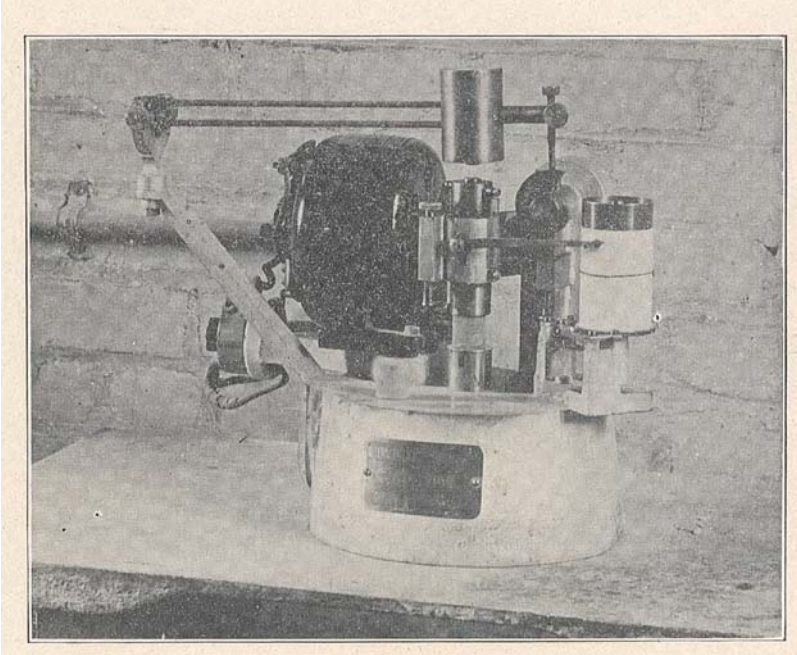

Plate 8. Page Impact Machine for Cementation Test.

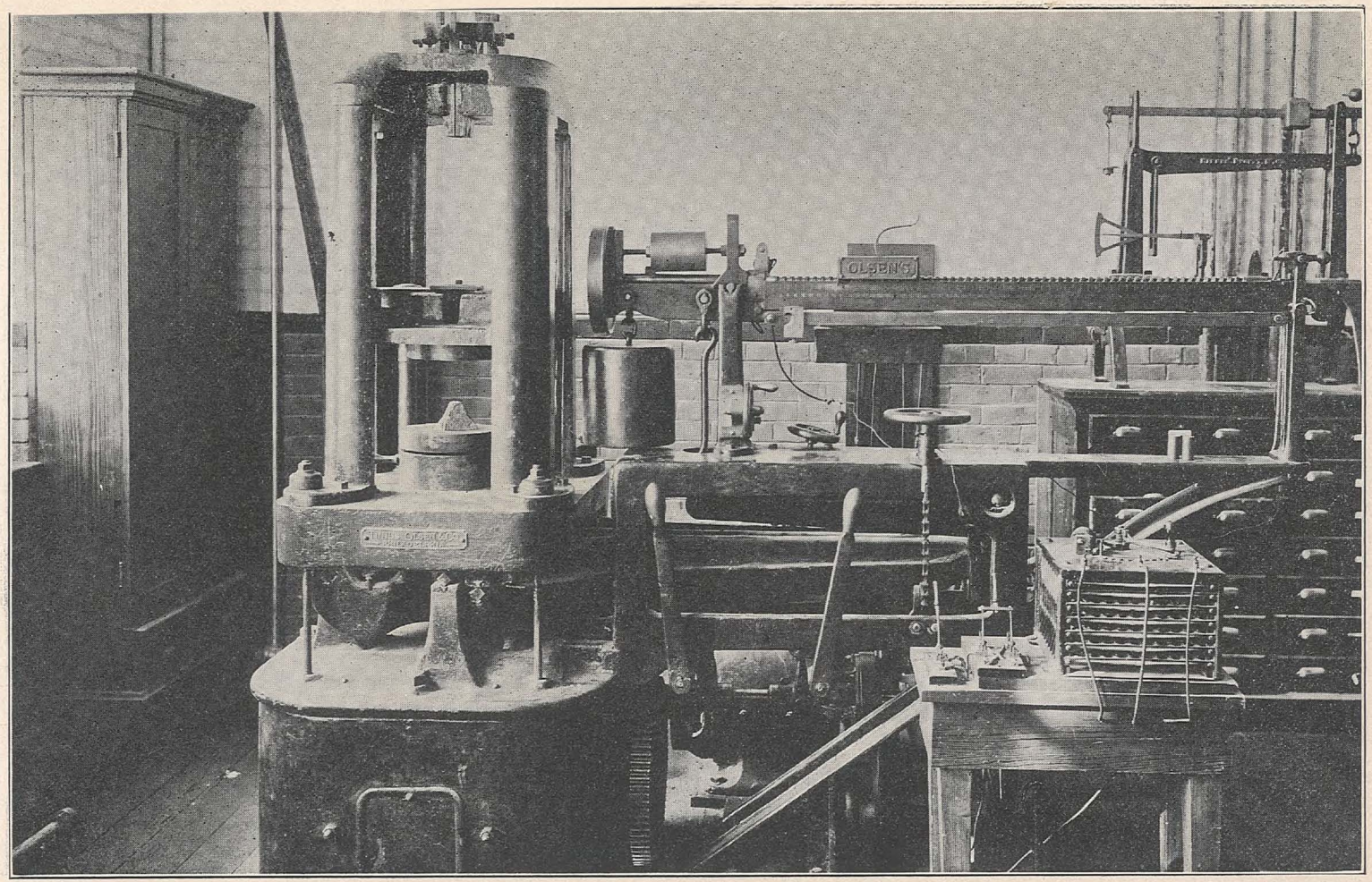

Plate 9. Olsen 100,000 Pound Testing Machine.

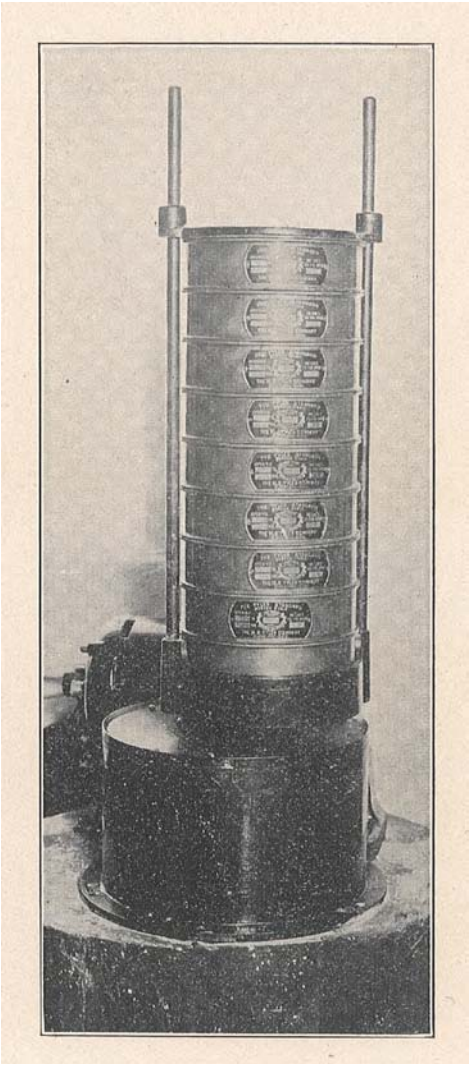

Plate 10. Mechanical Sieving Device.